# Review of Alternative Construction Methods for Transmission Towers

A REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF: MASTER OF ENGINEERING MANAGEMENT AT THE UNIVERSITY OF CANTERBURY

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TRANSPOWER

Transpower New Zealand Limited The National Grid

## Abstract

It is important to ensure that Transpower is prepared to deliver upcoming transmission tower refurbishment projects that are located on sites with difficult access. This project reviews the availability, capability and cost of utilising alternative construction methods and any associated wider issues. The focus of this report is on how Transpower can more effectively utilise helicopters and gin poles for transmission tower erection and material delivery on remote sites.

# Document Control

## Revision History

| Ver # | Date | Author | Change Description |
|---|---|---|---|
| **0.01** | 23/1/2014 | David Stevens | Document created |
| **0.02** | 24/1/2014 | David Stevens | Layout established, background information added |
| **0.03** | 25/1/2014 | David Stevens | Methodology section added |
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## Distribution List

| Ver # | Date | Recipient | Organisation |
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| **0.10** | 4/1/2014 | Peter Rasul | Transpower |
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# Executive Summary

**Project Purpose:** The purpose of this project is to make a contribution in ensuring that Transpower is prepared to deliver upcoming transmission tower refurbishment projects that are located on sites with difficult access. This project focuses on the availability, capability and cost of utilising alternative construction and material delivery methods.

**Background:** Transpower's predecessors built significant parts of the national grid in the 1950's and 1960s. During this time, the industry's safety standards were less stringent allowing for a wide variety of construction and material delivery techniques. This has resulted in many towers being located in positions where it may not be possible to utilise modern, safe practises, or if possible, then it will be very expensive. This is predominantly due to modern, safe practices requiring heavy vehicle access to transmission tower sites.

Transpower must be aware of all construction options available to ensure the most effective, long term approach is used when considering what access method to use. The factors to consider when determining the most effective approach are:

- The cost of refurbishment works
- The long term costs associated with the specific asset
- The safety risk profile of refurbishment works
- The long term risks of subsequent work and inspections on the specific asset
- The environmental impact
- The landowner impact

To assess these factors, information must be readily available to Transpower's project managers including:

- The alternative construction and material delivery methods that are able to be used
- A cost estimation process with supporting information
- A method of comparing safety risk profiles for different methods of construction and material delivery
- The limitations of the available alternative methods

A register is currently being developed to contain this information. The alternative techniques identified as feasible for Transpower to use for construction and material delivery in the future are:

- Helicopters for material delivery and tower erection
- Gin poles for tower erection
- Track mounted drilling rigs
- Helicopter portable drilling rigs
- Hand digging
- Track mounted concrete trucks
- Micro pile foundations

While conducting this project, wider issues were identified that are of concern regarding Transpower's ability to deliver refurbishment projects using alternative construction and material delivery methods including:

- A lack of a widely used safety risk profile comparison methodology
- Issues with Transpower's helicopter operator procurement process
- Limitations that Transpower's approved specification document TP.SS 02.08 *Use of Helicopters,* places on the future use of helicopters for construction services
- The capability to construct by gin pole is a dying art in new Zealand
- The future value of access tracks are difficult to assess

**Recommendations:**

It is recommended that the PAT gives approval for the following pieces of work to be completed:

1. To continue to populate the Alternative Methods Register with the following information:
    a. Up to date, relevant information on the availability and capabilities of machinery
    b. Up to date, relevant information on the availability and capabilities of crew and operators
    c. High level process maps for delivering the methods
2. To implement the Alternative Methods Register as per section 6.1.1 of this report
3. To give approval for the following packages of work:
    a. Assessing the feasibility of implementing safety risk profile comparisons as a standard process for project managers when considering using alternative construction methods
    b. A review of Transpower's helicopter operator procurement process with Sourcing Supply and Contracts from regarding issues identified in section 4.2.
    c. A review of TP.SS 02.08 *Use of Helicopters* approved specification regarding issues identified in section 4.3.
    d. A cost benefit analysis of resurrecting gin pole construction as a capability for the future
    e. An investigation into how to predict the future value of access tracks

The cost implications of completing this work will be minimal as it is recommended that engineers on the graduate programme are used to complete the work packages which may involve the current Project Manager when required.

# Contents

| Glossary | |
|---|---|
| **Alternative construction methods** | For the purpose of this report, alternative construction methods refers to any construction work that does not involve heavy machinery such as a crane, truck mounted drilling rig and concrete truck |
| **ATV** | All-Terrain Vehicle |
| **CAPEX** | Capital expenditure |
| **Checkpoint update** | An informal progress report used fortnightly to discuss issues and progress with the Project Supervisor |
| **Gin Poles (Derrick Construction)** | A gin pole, also known as floating derrick, is a rigid pole or lattice structure used for lifting |
| **HVDC** | High Voltage Direct Currant |
| **ISA** | International Standard Atmosphere |
| **NIGUP** | North Island Grid Upgrade Project |
| **PAT** | Project Approvals Team |
| **Project Manager** | for the purpose of this report, the Project Manager is a person empowered to make decisions regarding the type of access that would be used, this could include programme managers and engineers |
| **PSSG** | Project Support and Service Group |
| **SCORED Workshop** | a workshop that occurs before works begin to discuss risks and possible mitigations |
| **TEES** | Transpower Enterprise Estimating System |
| **TIPU** | Transpower Integrated Project Utility |
| **Tower Jacking** | a method of raising towers by between 1.5 and 3m |
| **Traditional access** | implementing an access track suitable for heavy machinery such as a crane or concrete truck |

# 1 Introduction

## 1.1 Introduction to Transpower New Zealand Limited

Transpower plans, builds, maintains and operates New Zealand's high voltage electricity transmission network. It is governed by the State Owned Enterprises Act 1986.

## 1.2 Company Structure

There are four major departments in Transpower:

- System Operator
- Grid Development
- Grid Projects
- Grid Performance

Major CAPEX Projects will usually flow from Grid Development through to Grid Projects to implement; and then to Grid Performance to maintain. Grid Projects is responsible for delivering all CAPEX works.

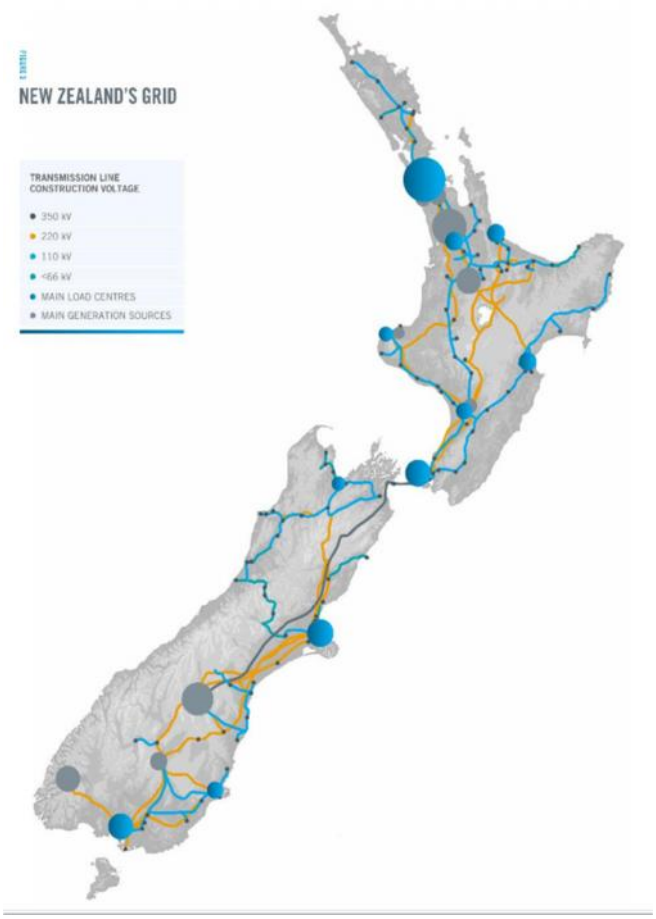


**Figure 1: New Zealand's electricity transmission network**

Within Grid Projects is the Project Support and Services Group (PSSG). The PSSG provide services that make it easier for Transpower's project community to achieve quality results. This project is run from within the PSSG.

## 1.3 Background

Transpower's predecessors built significant parts of the national grid in the 1950's and 1960s. During this period transmission towers were constructed using manual techniques such as site mixed concrete, hand dug foundations and towers erected by derrick construction. These construction approaches, then appropriate, are either no longer considered as safe or, in the case of gin pole construction, are dying out. This has resulted in many towers being located in positions where utilising modern safe practises may not be possible, or if possible, then very expensive. This issue became apparent during the HVDC line refurbishment which highlighting that, potentially, some future refurbishments could be very expensive.

There have also been situations where very large costs have been incurred due to difficult construction sites for transmission towers on recent, new build projects. These include the North Island Upgrade Project (NIGUP) and the Wairakei Ring Project among others. These projects had a number of very expensive access tracks (see J231 Claim August 2013 in supporting documentation).

When difficult construction sites are unavoidable for transmission towers, project managers will often call for a workshop (or similar) where stakeholders with a wide range of technical expertise, often from many companies, will share ideas to produce a cost effective solution. A one size fits all approach is not feasible due to the complexity of building on a difficult site which often has unique problems to overcome. It is important that Transpower is prepared for when old transmission tower refurbishment issues arise.

## 1.4 Problem Statement

Project managers are often required to facilitate the construction or major refurbishment of transmission towers located on sites with difficult access. Selecting the 'correct' method of construction and material delivery is highly complex with many, often unique, site specific challenges to overcome. It has been recognised within the Grid Projects Department that tools and information to make this decision making process easier and more robust would be highly valued.

## 1.5 Project Purpose

The wider purpose of this project is to make a contribution in ensuring that Transpower is prepared to deliver upcoming transmission tower refurbishment projects that are located on sites with difficult access. There are many initiatives in progress that will contribute to this wider purpose including developing a tower jacking method for lifting towers and the change from a regional to a national focus for refurbishment portfolios. This project focuses on making information available to Transpower's project community regarding the availability, capability and cost of utilising alternative construction and material delivery methods.

## 1.6 Report Purpose

This report is a snapshot in time of the progress to date for this project. Work will be on going in resolving the issues identified during this project pending approvals from the Project Approvals Team (PAT).

## 1.7 Scope

The scope has changed throughout the project process. A Project Change Request was used for a major scope change in light of the information gained while completing two site specific studies. Currently, the scope of this project is to:

- Create a register containing the availability, capability and cost of using alternative construction and material delivery methods: The 'Alternative Construction Methods Register'.
- Identify wider issues that will limit the capabilities that Transpower has available to deliver major transmission tower refurbishment projects located on difficult to access sites

# 2 Methodology

## 2.1 Project Management Best Practice

Transpower's project management manual for Grid Projects, *The Transpower Way* [1] was followed closely, where relevant, throughout this project. *The Transpower Way* is focused on the delivery of

major CAPEX projects. For this reason, some deficiencies were present in *The Transpower Way* methodology when applied to this project.

To ensure that best practice project management was adhered to, other recognised project management resources were sourced and utilised when *The Transpower Way* was not relevant or further information was required. *The Association for Project Management Body of Knowledge (PMBOK) Fifth Edition* [2] was used as an initial reference as it encapsulates the breadth of project management and demonstrates its depth. Essentially it defines the topics that comprise modern professional project management. *PMBOK* is however not in itself a specific methodology so further resources were sourced when required.

The main resource used to develop and implement the adopted stakeholder management plan was Assudani and Kloppenborg's *Managing Stakeholders for Project Management Success: an emergent model of stakeholders* [3]. The stakeholder management plan developed from this resource allowed for comprehensive up-to-date stakeholder information. See appendix H1 for the current stakeholder tracking tool developed to manage stakeholder information.

Many standard project management tools and techniques were used to deliver this project to date. Before a tool or technique was used, Paranakul, Lewwongcharoen and Milosevic's paper, *An empirical study on the use of project management tools and techniques across project life-cycle and their impact on project success* [4] was consulted. Appendix E1 was developed to track the project management tools and techniques used. This will enable a critical review of the project management process taken for this project to be more easily facilitated during the project close out phase.

There is the potential for minor business changes during the implementing phase of this project. To ensure a successful business change, John P. Kotter's *Why Transformations Efforts Fail* [5] was referred to which outlines the eight reasons why change fails in business.

## 2.2 Project Selection Process

The selected project had to meet requirements from the following parties:

- The University of Canterbury Master of Engineering Management course
- The Transpower Graduate Programme
- The Project Support and Services Group

To ensure all of the requirements were met, a project selection process was undertaken. A weighted matrix was used to identify the three projects that best fulfilled the established project requirements.

Three potential projects were presented to a senior management team on the 24/10/2013. The medium used to communicate the potential projects was an A3 charter and facilitated via a video conference meeting. The Grid Projects senior management team gave approval for an investigation into alternative construction methods for transmission towers to commence.

## 2.3 Project Team

A project team and Project Approvals Team (PAT) were established early in the project as outlined in *The Transpower Way* and Transpower's Project Governance Roles and Responsibilities Model as seen in appendix F1. Tables 1 and 2 below show the project team and PAT roles.

**Table 1: Project Approval Team (PAT)**

| Name | Position Title | Team Role |
|---|---|---|
| Vivien Winch | Programme Delivery Manager | Business/Project Owner |
| Nick Coad | Grid Works Project Manager | Project Assurance |
| Christian Carter | Project Support and Services Manager | Senior Supplier |
| Peter Cahill | Projects Manager | Senior User/Supplier |

**Table 2: Project Team**

| Name | Position Title | Team Role |
|---|---|---|
| Jason Price | Delivery Improvements Manager | Project Mentor |
| Gavin Murray | Programme Manager | Project Engineer |
| Peter Rasul | Transmission Line Construction Manager | Project Engineer |
| Steven Notman | Safety Practitioner | Safety Authority |
| David Stevens | Graduate Engineer | Project Manager |

## 2.4 Project Process

Following the project selection process, table 3 shows the project process taken to deliver the project to date.

| | Project Step | Date | Comments |
|---|---|---|---|
| Fortnightly checkpoint updates | Project Proposal | 31/10/2013 | Complete, approved by PAT |
| | Project Plan | 6/11/2013 | Complete and approved by PAT<br>Not updated since change request |
| | Project Charter | 6/11/2013 | Not updated since change request |
| | Progress Report 1 | 22/11/2013 | Reviewed by Project Owner |
| | Requirements Gathering | 3/12/2013 | Further requirements gathering is required in light of the sight specific study |
| | Change Request | 10/12/2013 | Recommended by experienced project manager Jon Masson |
| | Progress Report 2 | 16/12/2013 | Reviewed by Project Owner |
| | Site Specific Study / Recommendations Report | 24/1/2014 | Completed, awaiting approval from PAT |
| | Alternative Construction Methods Register | On going | Initiated as a result from the recommendations made during the site specific studies |
| | Final Report | 7/2/2014 | |
| | Project Close | - | To be completed |

## 2.5 Information Gathering

### 2.5.1 Interviews/meetings

The majority of the information was gained through conducting meetings and interviews with experienced stakeholders. Effective stakeholder management was essential in procuring the required information from the right people. The information about key stakeholders included:

- Preferred form of communication
- Project interest/influence
- Time commitments

- Restructure affect
- Annual Leave

Most of the information gained form stakeholders was highly subjective and from a single perspective. To structure the information flow from stakeholders, agendas were prepared and distributed prior to meetings where possible. Comprehensive meeting minutes were recorded using a Transpower Meeting Minutes Template. Information was then filtered and categorised in a bespoke excel template to make trends easily identifiable using pivot table functions. Seventeen organised meetings were held with internal and external stakeholders. Supplementary communications such as water cooler meetings, email exchanges and brief phone conversations were constant throughout the project and were also documented. To ensure that the information retained was accurate, the meeting minutes were provided for review by the meeting attendees.

The perspective and motive of the stakeholder needed to be considered when making recommendations from stakeholder comments. For example, the civil companies that were contacted saw the potential for future work and were eager to express their capabilities and so likely withheld some negative information about the feasibility of specific works.

### 2.5.2 Workshops

Two workshops were attended by the author that had relevant information to this project.

1. TESMEC conducted a stringing presentation to illustrate its latest machinery capabilities and recent innovations that had been made. This included the recent development of helicopter portable stringing machinery.
2. An internal Transmission Line Construction Workshop was held to share recent innovations and lessons learnt concerns. The use of helicopters to construct H poles in a future project in Paraparaumu was discussed.

### 2.5.3 Wider Research

Further information was obtained from the following sources:

- The Energy Library – Transpower's provider of scientific and technical information for the energy and engineering sectors in New Zealand
- Transpower's past projects - The Huntly Stratford 220 kV line commissioned in 1988
- New Zealand distribution companies – Marlborough Lines power pole works
- International transmission tower construction with helicopters
- LinkedIn – Overhead Transmission Line threads

# 3 Alternative Construction Methods Overview

There are many ways to construct, deconstruct and perform refurbishment works on transmission towers. Limitations are always placed on project managers when delivering these works. Having options available that are known to be able to be delivered is important. The more information available early in the project process, the more easily an effective solution can be chosen and delivered.

The alternative methods of construction that are the focus for this project are the use of helicopters and gin poles for major refurbishment projects. Construction and material delivery techniques that support these two methods were also investigated. The information gained on these methods is currently being consolidated into a register in excel to be made available for use by project managers. This register is identified as the Alternative Construction Methods Register.

## 3.1 Helicopters

Helicopters perform a wide variety of tasks on Transpower assets. While many of these tasks are on-going and frequently used, construction with helicopters has not been used for some time. There are project managers within Transpower and people within its service providers that have had vast experience with utilising helicopters for construction; however, the majority of this information is not documented. This creates a risk of lost capabilites when these people move on from the industry.

The CEO of Helicopters Otago Ltd. and the Operations Manager of HELiPRO, both of whom are senior pilots, were engaged to populate the Alternative Construction Methods Register with information and to quality check the work completed.

### 3.1.1 Past Construction Uses

**Huntly – Stratford Line**

The Huntly – Stratford (HLY-TMN A and SFD-TMN A) line, commissioned in 1988, used helicopters extensively to complete the following works:

- Tower erection
- Steel transportation to site for gin pole erection
- Gin pole transportation
- Concrete transportation (foundation pouring)

The majority of the information regarding these works that was obtainable was documented by video. The following issues regarding how these works could be completed today were identified:

- The project wase carried out before Transpower's *Use of Helicopters* Approved Specification document (TP.SS 02.08);
    - Twin engine helicopters were not a requirement
    - Minimum helicopter, operator and pilot requirements were not as stringent
- Riggers often were not following the minimum requirements for working aloft on lines (TP.SS 06.17);
    - Personal Fall Arrest Systems were not used
- Some foundations required hand digging;

- Limited to soil type
- Limited to *Confined space entry requirements for Transpower sites* (TP.SS 06.18) and ACOP for excavation and shafts for foundations (WORKSAFE NZ)

**Brownhill to Whakamaru North Line**

More recently as part of NIGUP, constructing the Brownhill to Whakamaru North (BHL-WHN A) Line, a helicopter was used to complete the following works for tower 157:

- Steel transportation to site for gin pole erection
- Gin pole transportation
- Concrete transportation (foundation pouring)

Little information is documented regarding the works though photos were taken and a general work instruction document was obtained.

The quoted price for implementing an access track to tower 157 was $172k. The quoted price for using a helicopter to gain access to tower 157 was $79k. This is a good example of where an alternative construction methods register could have been helpful to make an early decision regarding access. It also demonstrates a successful use of implementing alternative construction methods, though it is not common.

For this specific site, a minimalist access track was implemented for ATV and tracked vehicle access during summer months only. For this reason the construction work was completed in January 2012. The tower was erected using gin pole construction, though it could have been erected using a helicopter. Potentially the rational for using a gin pole was that, due to the weight of the tower, box sections were not possible to fly in. Images of the construction of tower 157 can be found in appendix A1.

### 3.1.2 Current Uses within Transpower

Helicopters are commonly used to perform a wide variety tasks on Transpower assets. These services can be categorised as seen in table 3.

**Table 3: Transpower's uses for helicopters by category**

| Category | Description | Comments |
|---|---|---|
| **Patrolling** | • Visual line patrolling<br>• Fault patrolling | No 'work' is undertaken |
| **Specialist services** | • Thermal imaging of joints<br>• UV Corona scanning<br>• High resolution video imaging<br>• Aerial Laser surveying<br>• Line work – positioning linemen onto towers etc.<br>• Insulator washing<br>• New line rout investigation | These services are mostly industry specific and require helicopter companies to invest in specialist equipment and training |
| **Construction Services** | • All external heavy lifting | Expected to be used for H pole erection on the Paraparaumu 220 kV Supply Connection Project within 2 years |
| **Fire Fighting** | • Use of monsoon buckets | These operations are usually not engaged by Transpower or its service providers |

### 3.1.3 Current Uses outside of Transpower

Helicopters have been used to support the utility industry since 1947, though since then, aircraft have become far more capable and reliable [6]. Transmission companies around the world have identified the benefits of using helicopters when faced with difficult environmental and access issues. For example; a Californian utility (Southern California Edison) used helicopters extensively to build a new 26.5 mile transmission line through the Angeles National Forest [7]. Helicopters were used both to limit the cost of implementing access tracks and to minimise the environmental impact on the Angeles National Forest.

Internationally, the forestry industry commonly uses helicopters to remove felled trees [8]. Helicopter logging is in many ways similar to transmission tower construction on difficult sites. While the precision required to place loads isn't as great, helicopter logging has many intrinsic safety risks, and are often used in challenging terrain and required to carry large payloads. A study of helicopter logging productivity by Lina E. Christian and Allen m. Brackley shows that with quality data capture, the cost gains of utilising helicopters over other available methods can be clearly demonstrated [9].

HELiPRO is currently engaging in works that are similar to erecting and deconstructing transmission towers. They are erecting and deconstructing weather masts that have 12, 900 kg sections with riggers catching and bolting tower sections together.

Marlborough Lines, a New Zealand electricity distribution company, frequently utilises helicopters for power pole erection due to the extremely challenging terrain they are faced within the Marlborough region. While the average power pole weighs around 600kg and is far simpler to erect than a transmission tower, there are similarities. Communications are on-going with an experienced project manager and an operations manager at Marlborough Lines to use for benchmarking purposes. Marlborough Lines will often use a variety of helicopters to complete a single project to ensure that a large expensive helicopter is not used to perform work that a smaller, less expensive

helicopter could complete. Marlborough lines always rates both the helicopter suitability and the experience of the pilot before allowing a helicopter operator to assist with the construction of their assets. Similar to Transpower's methodology, Marlborough Lines believes that ensuring safety and proper planning lead to a lowest cost rather than selecting the lowest tendered price blindly.

### 3.1.4 Availability

The availability of machinery capable of completing construction work on Transpower assets can be seen below in table 4. The helicopter companies engaged are Transpower's preferred suppliers with appropriate machinery for construction works.

**Table 4: Summary of helicopter availability in New Zealand for construction services**

| | HELiPRO | SKYWORK Helicopters | Helicopters Otago Ltd |
|---|---|---|---|
| **Fleet capable of performing construction services** | 3 x BK117 B1 | 1 x Squirrel AS355N<br>1 x K-Max(1) | 3 x BK117 B1 |
| **Pilots meet minimum requirements** | Yes – suggests competency requirements are necessary | Unknown | Yes – suggests that competency will not last long due to barrier to entry |
| **Operator meets minimum requirements (4)** | Yes | Yes | Yes |
| **Location(s)** | North Island and Christchurch (2) | Northland, Auckland and Coromandel (2) | Otago and Southland (2) |
| **Cost per hour ($)** | 3000 (2014) | 2850-3000 (2011) | 2950 (2014) |
| **Minimum charges** | -3 hour minimum per day<br>-2 hour minimum per half day<br>-No charge for weather days | -$2500/h ferry rate<br>-$1,475/day ground crew rate<br>-Unknown for K-Max(3) | -2 hour minimum per day<br>-Charge for whether days unknown<br>-Unknown for K-Max(3) |

- Note (1): The K-Max is currently situated in Wollongong, NSW, Australia. Skyworks welcomes enquiries for heavy lifting requirements in New Zealand
- Note (2): Can be used New Zealand wide
- Note (3): For use of the K-Max, the cost of transportation to New Zealand including MAF charges must be considered [10]
- Note (4): Operator minimum requirements are outlined in section 6.2 of Transpower's *Use of Helicopters* Approved Specification document (TP.SS 02.08)

### 3.1.5 Capability

The capability to perform construction works of the machinery identified in table 4 can be seen below in table 5.

**Table 5: Twin engine helicopter capabilities**

| Model | Number of Engines | Performance Class (3) | Max Lift Capacity (kg) (1) | Concrete Transport Capacity (kg) | Working wind limit (kts) (2) |
|---|---|---|---|---|---|
| **BK117 B1** | 2 | PC2 | 1,200 | 1000 + bucket | 15-30 |
| **Squirrel AS355N** | 2 | PC1-2 | 1,100 | 900 + bucket | 15-30 |
| **K-Max** | 1 | N/A | 2,700 | - | - |

- Note (1): The lift capacity is rated at ISA + 15°, normally 90% of max load is used
- Note (2): The wind speed for concrete delivery can be significantly higher than for tower erection due to the relative precision required for the tasks. Gusting winds have a negative effect on operations
- Note (3): The performance class classification for twin engine helicopters can be seen in appendix C1.

#### 3.1.5.1 Process Mapping

As part of the Alternative Construction Methods Register, generic, high level process maps have been created. Information from meetings with HELiPRO, Helicopters Otago Ltd. and work instructions from the Northern Grid Alliance were combined to produce the process maps. The Business Processing Mapping (BPM) tool, Bizagi is used. Bizagi has recently been selected by the PSSG as the tool and related methodology for how Transpower completes process mapping. The draft process map for erecting a transmission tower using a helicopter can be seen in appendix G2 and 3. The process maps that will be held in the Alternative Construction Methods Register are not intended to replace work instructions, and are instead to give project managers insight into the methods to enable more accurate cost and time estimates during the construction method decision making process. The decision making process that was followed throughout the site specific study was well documented and also developed into a process map which can be seen in appendix G1.

#### 3.1.5.2 Concrete Delivery Performance

The BK117 B1 and Squirrel AS355N have the capability to carry between 0.375 m^3 and 0.42 m^3 of concrete depending on the concrete density. Working with two concrete buckets to speed up turnaround time, over a 1km distance, both machines are capable of delivering around 8m^3 of concrete per hour. A competent ground crew is necessary to realise this performance.

Between 1985 and 1988 during the Huntly-Stratford line construction, the concrete performance delivery of helicopters was recorded. This information can be seen in appendix A2. Many of the helicopters used then can no longer be used for safety reasons so the information is redundant. The Alternative Construction Methods Register will have the capability record real concrete delivery performance figures as they are realised when working on Transpower assets in the future. This is so more accurate cost and time estimates can be made.

#### 3.1.5.3 Lift Performance

The affect that air density has on the lift performance should not be underestimated. The impact of air density on helicopter lifting performance will be supplied in the Alternative Construction Methods Register. This information will be simplified to give approximate maximum lift capacities

for a range of altitudes and temperatures. Helicopter operators are the experts at understanding the capabilities of their machinery under different conditions; however, understanding the limitations of the available helicopters in a project is useful [11]. Hot, high and humid conditions negatively affect helicopter performance.

### 3.1.6 Environmental Impact

All operations near Transpower assets should be planned at an early stage to minimise land owner impacts as stated in *Environmental management of existing assets* (TP.SS 05.10). Four major adverse impacts to landowners have been identified:

1. Noise
    a. Issues
        i. Primarily an issue in urban areas
        ii. More relevant to projects which involve extended operations in one location
    b. Mitigation
        i. Liaise with known objectors to Transpower helicopter operations
        ii. Select optimum time(s) of day to avoid high sensitivity periods
        iii. Setting access and departure routes so they are not over housing
        iv. Selecting helicopters with quieter noise signatures (often not possible)
2. Stock Injuries
    a. Issues
        i. Scaring of stock causing injury or damage
    b. Mitigation
        i. Preplanning in conjunction with land owners with sensitive stock
3. Vegetation Damage
    a. Issues
        i. Low level hovering can flatten taller crops such as maize
    b. Mitigation
        i. Where unavoidable, offers of compensation my need to be made
4. Dust Generation
    a. Issues
        i. Low level operations can produce considerable dust clouds which can impact many activities
    b. Mitigation
        i. Select landing sites with sealed surfaces or with grass
        ii. Dampen down bare sites

The long term environmental impact of implementing access tracks can be more severe than the impact from utilising helicopters for construction. It is difficult to make a direct comparison as 'environmental impact' can be subjective. Peter Nefzger, in his book; *Overhead Power Lines: Planning, Design, Construction*, suggests that environmental constraints are of increasing importance around the world [12]. The permanent and temporary effects on the environment are usually quantifiable; however, public reaction to a project may sometimes be emotional. Therefore, the evaluation of the environmental impact of projects is complicated and involves aspects that can only be analysed from a qualitative point of view.

### 3.1.7 Safety

There are many safety issues to consider when using helicopters for construction services. However, there are also safety concerns associated with implementing major access tracks, accessing work sites with heavy machinery and performing construction works with a crane. Section 4.1 of this report suggests a way to compare safety risk profiles.

## 3.2 Gin Pole (Derrick) Construction

A gin pole, also known as floating derrick, is a rigid pole or lattice structure used for lifting. Gin pole construction is an internationally recognised technique for erecting transmission towers [12].

A brief overview of the method for using a gin pole for transmission tower construction is as follows:

1. The gin pole is positioned on base plate and secured to the towers stubs and pre placed tifor anchors
2. The legs and spiders are lifted into place and secured
3. The gin pole is raised into a floating position and secured to the tower and tifor anchors
4. Panel sections are lifted into place and secured
5. Steps 3 and 4 are repeated until the tower is assembled
6. The gin pole is lowered through the centre of the tower and removed
7. Minor steel members that could not be positioned due to interference with the gin pole are carried up by riggers and secured

Note: A high level process map is currently being developed outlining the gin pole construction process to be stored in the Alternative Construction Methods Register.

Tower erection using a gin pole is a highly skilled job that requires an experienced and competent leading hand to ensure safe operation. There is inherent complexity in using a floating derrick and the damaging of steel members is possible if undertaken incorrectly.

### 3.2.1 Past Construction Uses

As mentioned previously in section 3.1, a gin pole was used to erect tower 157 in 2012 on the Brownhill to Whakamaru North (BHL-WHN A) Line. A specialist contractor from the United Kingdom was sourced to complete the works. The contractor shipped over their own 70 foot aluminium gin pole with a 3.5 Tonne lift capacity. Images taken during work on tower 157 can be seen in appendix A1.

Gin poles have not been used for construction (by New Zealand based service providers) since the late 1990s. They were used extensively as a safe and comparatively inexpensive method of tower erection. The gin pole enabled towers to be erected on difficult sites where otherwise expensive crane pads would have to be constructed or helicopters used.

### 3.2.2 Availability

The availability of gin poles and related equipment are currently being correlated and are being populated in the Alternative Construction Methods Register. A summary of the information sourced to date can be seen below in table 6.

**Table 6: Gin pole availability in New Zealand**

| | Transpower | Electrix | Transfield |
|---|---|---|---|
| **Number Owned** | 1 | 1 | 1 |
| **Location (1)** | Omaka Training Centre, Blenheim | Hamilton | Otahuhu, Auckland |
| **Commission state** | - | - | - |
| **Competent supervisor and ground crew** | • Only a few people left in the industry who have used gin poles though will likely exit within ten years<br>• Thought to have the ability to assemble a competent crew though would have to be assembled from across the country and across providers | | |
| **Built** | 1968 | | |
| **Secondary equipment(2)** | - | - | - |
| **Comments** | Transpower's gin pole if for training purposes though it could be used in an emergency | - | - |

- Note (1): There are potential more gin poles in old depots throughout New Zealand though are largely forgotten
- Note (2): To operate a gin pole, secondary equipment is required including tirfour anchors, guys, a winch, pulleys, rope etc.

### 3.2.3 Capability

The capabilities of the gin poles identified above in table 6 can be seen summarised below in table 7.

**Table 7: Gin pole capabilities**

| | Transpower | Electrix | Transfield |
|---|---|---|---|
| **Maximum lift capacity** | 2T | 2T | - |
| **Length (feet)** | 43' or 28' | - | - |
| **Weight (kg)** | - | 375 | - |
| **Live line capability? (1)** | No | No | No |
| **Maximum wind (kts) (2)** | 30 | 30 | 30 |
| **Access requirements** | Light trailer or helicopter access possible | | |

- Note (1): Gin poles can be constructed using insulating materials and so can be suited to live line work
- Note(2): Gusting winds have a large effect on operations

Gin poles are highly versatile and can be positioned on difficult construction sites. The gin pole itself can be broken down and easily transported. As with helicopters, tower construction with a gin pole has no tower height restriction, unlike a crane.

### 3.2.4 Safety

Consensus amongst those in Transpower and its service providers who have experience with gin poles is that it can be a very safe method of construction in comparison to using cranes and helicopters. Safety risk profiles will be compared using the methodology outlined in section 4.1 of this report and implemented in the Alternative Construction Methods Register.

The complex process of gin pole construction requires highly structured works procedures. The inherent safety risks can be largely mitigated by using an experienced leading hand and a well-trained crew.

## 3.3 Methods to Assist Helicopter and Gin Pole Construction

When used appropriately helicopters and gin poles can offer cost, safety and environmental benefits for transmission tower construction. However, helicopters and gin poles have limitations and may not be suited to a specific site's requirements. Possible methods to assist helicopter and / or gin pole construction can be seen below in table 8. The CEO of CW Drill Ltd and the Managing Director of Civil Group New Zealand Ltd. were engaged. Both companies have experience with construction drilling in difficult locations.

**Table 8: Material delivery and construction methods that can assist helicopter and / or gin pole construction**

| Description | Access | Limitations | Comments |
|---|---|---|---|
| Track mounted drilling rigs | Proposed by CW Drill to have similar access as ATV vehicles, 2.5m wide | -Requires clear entry (fences etc.)<br>-Must be transported to site<br>- Wet grassy slopes are hazardous | -Have been used on NIGU<br>-Civil Group and CW Drill engaged to further understand capabilities<br>-Similar operating costs to standard drilling rigs once in position |
| Helicopter portable drilling rigs | Helicopter limited | -QM750 and similar rigs max diameter 150mm to 200mm<br>-Suited to micro-pile construction | -Minimum six helicopter trips<br>-Up to 20 helicopter trips depending on depth required<br>-Similar operating costs to standard drilling rigs once in position |
| Hand-digging | Nearly unlimited | -Safety concerns; confined space,<br>-Limited to soil conditions | -Possible but with many safety implications<br>-Review ACOP for excavation and shafts for foundations (WORKSAFE NZ)<br>-TP.SS 06.18 *Confined space entry requirement s for Transpower sites* |
| Micro-piles | Drilling rig entry limited | -Not recently used by Transpower<br>-Would require specific design and testing | -Used successfully on a Sothern California Edison (SCE) transmission line project<br>-Similar method (Ishbeck Anchor Piles) was used on Huntly Dev A line for one structure |
| Other foundation types | Heavy vehicle or helicopter | -Similar issues to cast-in-situ piles | -Will be considered for the most appropriate on a case by case basis<br>-TP.DL 01.01 *Transmission line foundation design* |
| Tracked concrete trucks | Superior to heavy vehicles | -Unknown availability<br>-Unknown access requirements<br>-Must be transported to site<br>- Wet grassy slopes are hazardous | -Access capabilities are approximately equivalent to an ATV |
| ATV material and personal delivery to site | As per TP.SS 06.26 | -Towing capacity is limited to 50% of the gross vehicle mass<br>-Prefer dry conditions<br>-Safety implications with rolling vehicles | -TP.SS 06.26 Vehicle use in off-road situations |

## 3.4 Alternative Construction Methods Summary

Transpower has the potential to utilise alternative construction methods safely by implementing some minor changes as illustrated in section 4 of this report. While helicopters and gin poles are used frequently outside of New Zealand for transmission tower construction, Transpower is limited to the equipment, machinery and experience of people within New Zealand.

The helicopters readily available to Transpower are not purpose built lifting aircraft and so have a higher intrinsic risk associate with using the aircraft for this purpose. The average lift capacity of the available aircraft located in New Zealand is typically lower than what would be used for similar construction work overseas where helicopters like the Sikorsky Skycrane are used. The Skycrane has a 10 tonne lift capacity which allows for large, pre-assembled tower sections to be transported with wide safety margins resulting in fewer, safer trips. While it would be possible to bring in heavy lift helicopters to Nez Zealand for a specific project requiring many tower builds, for the refurbishment tasks that are of focus for this project, economies of scale are likely not possible.

It is possible to procure equipment, machinery and an experienced crew from outside of New Zealand to facilitate a gin pole construction as described in section 3.1.2. It is, however, likely that gin poles will be the preferred method of refurbishment for many upcoming refurbishment jobs due to their low cost and minimal access requirements. It will then be in Transpower's best interest to ensure that the capability to construct transmission towers with gin poles within New Zealand is maintained now and into the future.

# 4 Wider Issues

Wider issues discovered during research and the site specific studies can be seen in appendix D1.3. The major issues have been summarised below in this section.

## 4.1 Safety Risk Profile Comparison

### 4.1.1 Current situation

Section 6.1.1 of Transpower's *Use of helicopters* specification document states that, '[Helicopter] use is to be limited to work tasks where alternative methods either have a poorer **safety risk profile**, and/or other methods have a disproportionately greater cost or unrealistic time requirements'. As a result, for project managers to justify the use of helicopters to assist with major refurbishment a risk profile comparison should be completed.

Transpower has robust processes in place to identify and mitigate risks prior to and throughout a project. The currently preferred method is to conduct a SCORED Workshop followed by subsequent monthly updates throughout the life of the project. SCORED workshops usually occur after the tendering process. The outputs from SCORED workshops should be stored in TIPU as material to refer to and update by Transpower employees and Service Providers.

The ability to compare risks between proposed construction and material delivery methods before the tendering process is difficult due to the highly subjective nature of risk assessments. Safety risk assessments should be completed by a team of people, preferably spanning multiple disciplines.

Transpower has a methodology to facilitate risk profile comparisons outlined in the Transpower Approved Standard, *Safety-by-Design Strategy and Application.* The current issues identified regarding this standard in the context of this project are that:

- There is a general lack of understanding of the standard throughout Transpower
- It is not currently used effectively
- It is not understood when a safety by design comparison should be made
- An assumption exists that safety by design applies only to new processes and new types of equipment and not for reviewing existing processes and equipment types
- Current risk profiles are in many different formats increasing the difficulty for comparison
- Generic risk assessments are often used which may not take into account site specific risks
    - Note: Site specific risks are important to consider for sites with difficult access issues

A risk profile comparison should be completed when any alternative construction or material delivery method is considered for use. This in itself creates a barrier to the use of alternative methods. Hence, there is a tendency to use traditional construction and material delivery methods without a structured approach to assessing risk benefits associated with other options. An unstructured approach to comparing risk has the following implications:

- Potential for using a process or equipment that has a greater associated risk
- Potential for missed cost saving opportunities by assuming risk of alternative construction and material delivery techniques have a higher risk profile than traditional methods

- In the case of an incident, the lack of clear and consistent justification for the selected method (whether traditional or alternative) may have high consequences as per the *NZ Health and Safety in Employment Act 1992*

### 4.1.2 Proof of Concept - Risk Profile Comparison

As a proof of concept, a risk profile comparison was completed. The test case risk profile comparison follows the process outlined in the *Safety-by-Design* Approved Commentary. For a risk profile analysis to be implemented as standard practice when a comparison of techniques or equipment is required, the process must:

- Fit within the usual risk analysis process currently taken by Project Managers and Service Providers
- Not take excessive time (time requirement yet to be analysed)
- Show obvious value
- Have stakeholder buy in
- Be repeatable

The test case selected was to compare the risk profiles for using either a crane or a helicopter to complete the assembly and erection of a transmission tower. The information available to create the risk profiles for this work was in different formats than is required by the *Safety-by-Design* standard and so had to be adjusted to be consistent. There was some subjective interpretation necessary to complete this. Job Hazard Analysis Sheets from the Northern Grid Alliance were combined with a HELiPRO Risk Assessment Form to assess the relevant risk profiles. The resulting risk profiles can be seen below in figure 2 . The representation of the numerical values can be seen in appendix B1.

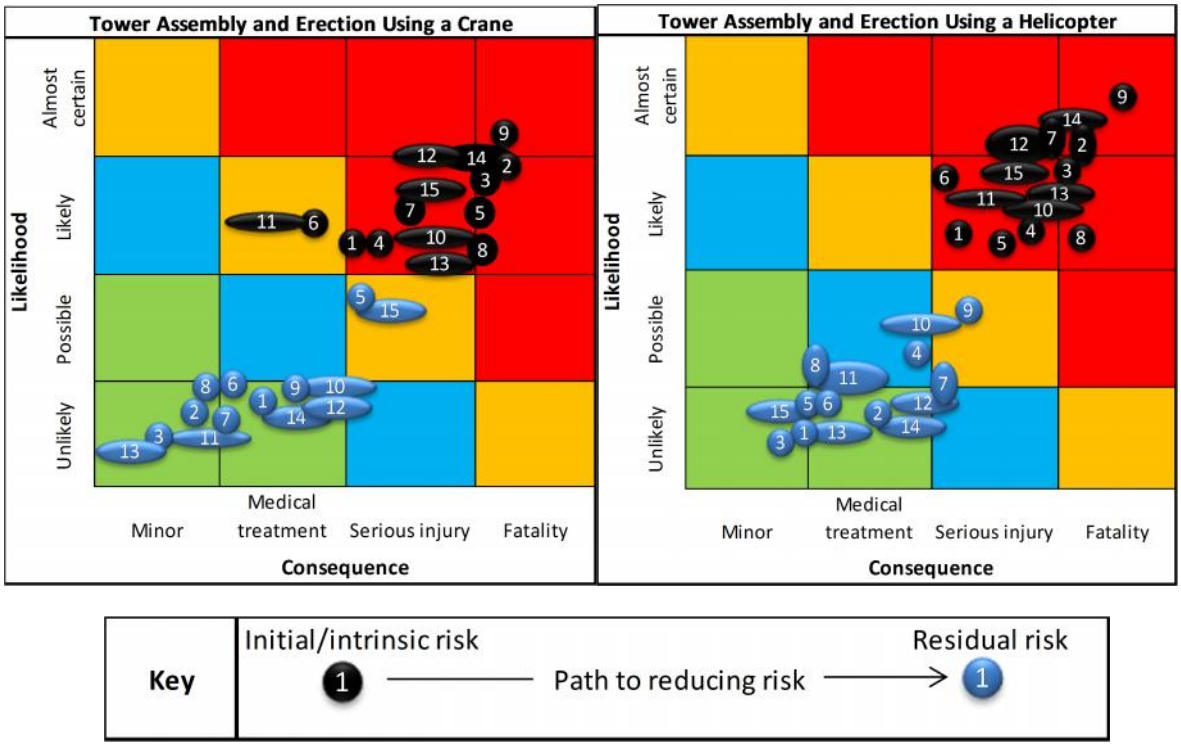


**Figure 2: Risk profile comparison for the assembly and erection of a transmission tower**

This proof of concept case is generic and does not consider issues that can be specific to a site. It can be seen clearly that performing this task using a crane has a slightly preferable intrinsic and residual risk profiles.

The results of this comparison could change significantly when being applied to a specific site. For example; if the specific site to be worked on is located on the leeward side of a mountain and subject to changeable weather conditions, the risk associated with processes 9, 10 and 11 for helicopter operations will increase significantly. A further example of how risk profiles can change is that HELiPRO have recently had a significant upgrade in the communications systems they have installed in their BK117's allowing for hands free operation by the pilot. Considering this risk mitigation, the residual risk of process 7 will be decreased.

The risk profile comparison in figure 2 for tower assembly and erection is only one work procedure of many that must be analysed when considering using alternative methods. The safety risk of the entire asset life cycle should be considered. These could include but are not limited to:

- Earthworks
- Foundations
- Drainage
- Future maintenance
- Future inspection
- Emergency access
- End of life deconstruction

## 4.2 Helicopter Operator Procurement

By engaging two of Transpower's preferred helicopter operators, HELiPRO and Helicopters Otago Ltd., wider issues regarding Transpower's procurement processes were identified. An unrelated recent poor performance from one of Transpower's service providers on a major stringing job has highlighted the risk Transpower has of being exposed to monopoly suppliers.

Helicopter operators are concerned that maintaining the capability to work on Transpower's assets will not be economically viable in the future. Though Transpower is a major customer, these helicopter operators are hesitant to invest in expensive machinery, equipment and training specific to Transpower's requirements as work is not guaranteed.

HELiPRO and Helicopters Otago Ltd. have made comments, seen in table 9, regarding Transpower's procurement process.

**Table 9: Helicopter operator comments regarding Transpower's procurement processes**

| | Helicopter Operator Preference/Comments | Potential Implications |
|---|---|---|
| **1** | To specialise in specific tasks | -A monopoly market could be created for specific works<br>-Better quality and safer work |
| **2** | A guaranteed number of hours in the short to medium term to secure capability investments | -Ensures capabilities will exist when they are required<br>-An obligation to supply work |
| **3** | To source operators based on speciality not region | -Better quality of work and savings from economies of scale<br>-Aligns with Transpower's new national focus |
| **4** | For relatively simple work on Transpower assets to be distributed to operators with focus on the future | -Avoid risk of a monopoly by ensuring required pilot competencies are current in multiple operators<br>-A less cost effective approach due to loss of economies of scale |
| **5** | Safety is improved when specific work is repeated often | -Safer work practices<br>-Processes become more refined and competencies are increased |
| **6** | A yours to lose system is more appropriate than a tendering process | -A less competitive price is obtained |

The comments made in table 9 need to be considered in context. Most contractors would prefer guaranteed work and to be the lone supplier of a specialist service to a major company. However, Transpower has a self-interest to ensure that the capability for helicopter operators to work on Transpower assets is maintained. A minor improvement project needs to be completed to investigate if a change in Transpower's procuring process for helicopters should be completed with collaboration from Sourcing Supply and Contracts.

## 4.3 TP.SS 02.08 *Use of Helicopters* Approved Specification

The site specific studies conducted during this project exposed some limitations and issues with the Transpower's approved specification document. These have been summarised in table 10 below.

**Table 10: Limitations and issues identified in TP.SS 02.08**

| | Limitation / Issue | Impact / Comments |
|---|---|---|
| **1** | Some project managers see the specification as a guide only | Potentially unsafe works completed that do not follow the specification |
| **2** | It was noted that TP.SS 02.08 was written with collaboration of two helicopter operators | Some of the requirements in the document are thought to have been included to eliminate compaction resulting in excessive requirements |
| **3** | Pilot requirements are a barrier to entry for new pilots (20 hours of transmission line work must be logged) | Many of the pilots operating on Transpower assets today built their experience before the introduction of this specification document and so now comply |
| **4** | By 2016, TP.SS 02.08 requires all helicopters performing lifting operations to be Performance Class 1 helicopters | PC 1 machinery currently is not available for use in New Zealand and is unlikely in the near future<br>The K-Max helicopter is purpose built for repetitive external lifting operations [13]. It was designed around the cargo hook donning a single seat and comparatively unobstructed views for the pilot. The simplicity of the K-Max presents a machine that is inherently safe and reliable. It has a two intermeshing main rotors which means all of the engines power is converted to lift without the need to drive a tail rotor. The K-Max is however a single engine machine and so cannot be used for lifting operations for Transpower despite being very suitable and likely more safe for lifting operations than other available options in New Zealand. |
| **5** | BK117's do not comply due to no airframe filter | When BK117s are used for work on Transpower assets, a mitigation plan and waiver must be used |
| **6** | Section 6.1.1 states '[helicopter] use is limited to when other methods have a disproportionally greater cost' | Access tracks may be implemented without considering helicopter access due to the perception that using helicopters is excessively expensive<br>This section contradicts with TP.SS 02.19 *Management of access ways* section 8.3.1 which states 'The method of access provided is to be that which achieves the best result for the lowest long term cost' |
| **7** | Section 6.1.1 states '[helicopter] use is limited to when other methods have a poorer safety risk profile' | The wording suggests that in the case of similar risk profiles, helicopters should not be used which may result in more expensive refurbishment works<br>Safety risk profiles are not often compared currently in Transpower, see section 4.1 |

A review of the *Use of Helicopters* approved specification document needs to be considered. TP.SS 02.08 may require revision to remain realistic considering the resources available and consistent with other Transpower standards. See section 6 of this report for further detail.

## 4.4 Gin Pole Construction

The wider issues exposed during the site specific study conducted during this project associated with gin pole construction are summarised below in table 11.

**Table 11: Limitations and issues identified with gin pole construction**

| | Issues / limitations | Impact / comments |
|---|---|---|
| **1** | Readily available information regarding the availably of gin poles and their associated equipment within New Zealand is limited | Project managers may be hesitant to use gin poles due to the unknown availability<br>The Alternative Construction Methods Register will partially mitigate this issue |
| **2** | Gin pole construction is considered a dying art | Transpower has a responsibility to ensure transmission tower construction by gin pole remains a viable option<br>If allowed to die, there may be missed opportunities for safe and inexpensive tower erection in the future |
| **3** | Gin pole construction requires a highly skilled leading hand, many of whom will be leaving the industry within the next 10 years | Competent leading hands will become difficult to source unless the training of new site supervisors is completed and maintained |
| **4** | Gin pole construction requires a well-trained rigging crew | Competent rigging crews will become difficult to source unless part of their lines training programme involves construction by gin pole |

Further investigation needs to be completed to determine the following:

- If gin pole construction is required to be maintained as a capability available to Transpower in the future and if so, then;
- What actions must be taken to ensure this is true not and into the future

## 4.5 Future Value of Access Tracks

TP.SS 02.19 *Management of access ways* section 8.3.1 states 'The method of access provided is to be that which achieves the best result for the lowest long term cost'. To ensure that this is achieved, the future value of an access track needs to be considered. After construction works are completed, access tracks are often managed in the following ways:

1. Maintained to allow heavy vehicle access
2. Width reduced and reinstated to allow for ATV access only
3. Completely reinstated back to original condition

Option 3 offers no future value associated with the access track. For options 1 and 2, the future value of the track should be considered before making a final decision regarding how the asset will be accessed. It is difficult to place an exact figure on the future value of an access track as they can serve as an access path to conduct a wide variety of works over a 50 year lifecycle including:

- Yearly or six monthly inspections
- Heavy plant replacement
- Insulator replacement
- Hardware replacement
- Signage replacement
- Foundation upgrades
- Tower painting

- Vegetation control

The future value of an access road is site specific. For example; a transmission tower that is exposed to severe weather will likely require more hardware replacement events over 50 years than a relatively sheltered tower.

While performing the works listed above is possible to complete without the use of an access track, it may introduce excessive on-going costs for the asset. The cost of maintaining the specific access track must also be taken into account.

Further, non-economic considerations that need to be taken into account when deciding considering the future value of an access track are:

- The ability to respond to an emergency
- The safety implications of performing future work without access tracks
- The safety implications of using poorly maintained or difficult access tracks

A simple and accurate method of predicting the future value of an access track would be highly valued when project manager is deciding what method of access to use. The Alternative Construction Methods Register would benefit from this information.

## 4.6 Wider Issues Summary

The wider issues identified during this project present real and imminent barriers to Transpower's ability to effectively complete future major refurbishment works. The majority of these issues can be resolved with very little capital investment though will require a significant time investment to further investigate the issues and implement solutions. The recommendations developed may require further investment. For example; if it is deemed necessary to maintain the capability to erect towers by gin pole, then a training programme will have to be delivered as well as the potential to invest in some equipment.

# 5 Conclusions

Currently, Transpower is not adequately prepared to deliver major refurbishment work on transmission towers with difficult access due to:

- Negative perceptions regarding the safety of alternative construction and material delivery methods
- No widely used methodology exists to compare safety risk profiles
- Potentially unnecessary limitations placed on alternative methods from Transpower standards
- A limited awareness of potential alternative methods from project managers
- Limited information regarding the cost, availability and capability of alternative construction and material delivery methods

Continuing to populate the Alternative Construction Methods Register and then deliver it to the business is required to address many of these issues. Further work is however recommended as many imminent issues were identified during this project.

A major limitation to using helicopters for the construction of transmission towers for Transpower is the lack of readily available, purpose built machinery. New Zealand does not yet have the market for helicopter operators to invest in medium and heavy lift helicopters. Transpower, while a valued customer, cannot offer sufficient guaranteed work for helicopter operators to make such a large investment. Transpower must then work with helicopter operators to ensure that the equipment, process and training investments made will align with Transpower's needs and expectations where possible.

Gin pole construction is considered a dying art in New Zealand as many of the personnel with the appropriate experience will be leaving the industry shortly. This issue has been raised by the Lines Team, yet little action has been taken. Gin pole construction is an internationally recognised construction method that has many benefits over other construction methods including a relatively low cost. Transpower has the systems, equipment and experienced people in place to deliver an effective gin pole revival programme. However, the longer the construction technique is left unused, the further this capability will decay and the more difficult it will be to revive. Transpower risks either not benefiting from having gin pole construction available or, if necessary, a costly revival programme if action is not taken quickly. If it is decided through further investigation that the cost of maintaining gin pole construction as a capability will not deliver a return on investment, then the decision to allow gin pole construction to die out may be made.

The PSSG delivers effective tools and techniques to project managers to ensure a robust project management process. A simple and effective method of comparing safety risk profiles is valuable to project managers as it encourages wide thought about specific tasks and can result in a change of construction method that has less risk associate that was not obvious from the outset of a project. Documented justification of protect delivery methods is also important due to auditing requirements. While assessing risk is always completed during Transpower projects, a consistent and documentable approach is not widely used though could be simply implemented.

The wider issues identified in this project need also be addressed if Transpower is to be well prepared for upcoming difficult refurbishment projects that are located on sites with difficult access.

This includes a way in which project managers can estimate the future value of an access road which will enable a better informed decision making process with regard to safety risk and cost when considering what method of access to pursue for a specific site. A review of the current, *Use of Helicopters* specification document will ensure safe practices are maintained and that unnecessary barriers are not placed on project managers. The culmination of this information, if maintained and delivered appropriately will be highly valuable to Transpower for delivering major refurbishment projects on transmission towers on sites with difficult access.

# 6 Final Recommendations

## 6.1 Recommended Further Work

Ensuring Transpower is prepared for upcoming refurbishment work on transmission towers that are located on sites with difficult access requires on-going work. The recommended future work outlined in this section is that only which is relevant to the scope of this project.

### 6.1.1 Implementation of the Alternative Construction Methods Register

The process of implementing the Alternative Construction Methods Register is briefly outlined below. Note that some of the work toward implementing the register has already begun. The current Project Manager should continue with the work necessary to further populate and implement the Alternative Construction Methods Register.

#### *6.1.1.1 Quality Assurance*

To ensure buy in from internal stakeholders, the quality of the information must be high. The PAT, project team and external stakeholders will complete quality checks. The assumptions made and sources of data must be clearly stated for Transpower's project managers to have confidence in the register.

#### *6.1.1.2 Benchmarking of the current situation*

If benefits are to be realised, the current situation must be thoroughly understood. The general process is currently known, though this varies considerably between project managers and from project to project. The time taken to find information regarding alternative construction methods must be recorded and documented so a before and after comparison can be made when the register has been rolled out. The time saved in sourcing information is a real economic benefit.

A more difficult comparison to make is the benefit gained from making better construction method decisions. Projects will be looked at retrospectively and assessed if an alternative method would have been more suitable considering:

- Long term cost
- Safety
- Environmental impact
- Landowner impact
- Quality of work completed

#### *6.1.1.3 Roll out*

Internal stakeholder buy-in is necessary to realise benefit from the Alternative Construction Methods Register. The register needs to be readily available to all stakeholders so will be situated on Transpower's file sharing network, The Hub.

To raise awareness, a workshop or similar event will be held to promote the register and will supply training how to gain the most benefit when using it. On-going training will be offered.

#### *6.1.1.4 Continuous Improvement*

The register must remain current and accurate to be effective. Input from those who use the register is vital in ensuring this. A Transpower employee will at all times have ownership of the register. The responsibility of the owner is to ensure that:

- Feedback from those who use the register is sourced and acted upon
- Relevant information is added where appropriate
- Information regarding new machinery, construction techniques and relevant changes to standards are included
- Redundant information in eliminated
- When the register itself becomes redundant, it must be terminated or amended

### 6.1.2 Wider Issues

On approval from the PAT, the wider issues identified in this project should be packaged into minor change projects and executed. The results from these projects can be implemented into the Alternative Construction Methods Register where appropriate.

## 6.2 Recommendation Summary

4. To continue to populate the Alternative Methods Register with the following information:
    a. Up to date, relevant information on the availability and capabilities of machinery
    b. Up to date, relevant information on the availability and capabilities of crew and operators
    c. High level process maps for delivering the methods
5. To implement the Alternative Methods Register as per section 6.1.1 of this report
6. To give approval for the following packages of work:
    a. Assessing the feasibility of implementing safety risk profile comparisons as a standard process for project managers when considering using alternative construction methods
    b. A review of Transpower's helicopter operator procurement process with Sourcing Supply and Contracts from regarding issues identified in section 4.2.
    c. A review of TP.SS 02.08 *Use of Helicopters* approved specification regarding issues identified in section 4.3.
    d. A cost benefit analysis of resurrecting gin pole construction as a capability for the future
    e. An investigation into how to predict the future value of access tracks

**Table 12: Recommendations summary**

| Work Package | Subject to PAT approval? (1) | Responsible (2) | Estimated Time to Completion |
|---|---|---|---|
| **1** | Yes | David Stevens | 1 month + on-going |
| **2** | Yes | David Stevens | 2 months + on-going |
| **3a** | Yes | Graduate | 1 month |
| **3b** | Yes | Graduate | 3 months |
| **3c** | Yes | Graduate | 1 month |
| **3d** | Yes | Graduate | 1 month |
| **3e** | Yes | Graduate | 2 months |

- Note (1): The existing PAT should be used for subsequent work on this project
- Note (2): For work packages 3a to e, an engineer on the graduate programme is recommended to be responsible. This may or may not be the current project manager

The expected time taken to complete the works is based on the time taken to complete this project to date multiplied by the expected amount of work required. On approval of work packages 3a to e, the assigned responsible graduate engineer will prepare a project proposal subject to further approval from the PAT. More accurate time and scope information will then be available.

The project team used for this project may not be appropriate for subsequent works and so a new project team should be selected and engaged where appropriate by the responsible graduate engineer.

The forecasted cost of all subsequent work is minimal. The time of the assigned graduate engineer is billed separately. However, due to the heavy time requirements needed to complete all of the recommended work, the Graduate Programme Coordinator must also be engaged to give approval. The graduate programme runs a Graduate Experience of Project Planning (GEPP) activity that involves completing a business improvement project within Transpower which could be an opportunity to deliver these work packages.

Any future costs associated with this project will be subject to PAT approval as per the original project plan.

# 7 Lessons Learned

Many lessons were learnt during project process so far and can be seen in appendix I1. Major lessons were recorded to be viewed later on subsequent projects. The majority of 'mistakes' that the author made involved time and stakeholder management.

Transpower has a lessons learnt procedure which is currently being reviewed by the PSSG. The personal lessons learnt register seen in appendix I1 should be used by the author in conjunction with Transpower's wider lessons learnt register when engaging in future projects.

This project has allowed for the author to build a network of people across three of Transpower's four departments and within many of its service providers. A wide understanding of how Transpower operates as a business was necessary to deliver this project, the knowledge of which will be valuable for the author in future work for Transpower.

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## 8.1 Relevant Documents

### 8.1.1 Transpower Standards

**TP.DL 01.01** *Transmission line foundation design*

**TP.SS 02.08** *Use of helicopters*

**TP.SS 02.19** *Management of access ways*

**TP.SS 04.10** *Tower Structures, and foundation design*

**TP.SS 05.10** *Environmental Management of existing assets*

**TP.SS 05.20** *Stakeholder liaison*

**TP.SS 06.17** *Minimum requirements for working aloft on lines and substations structures and equipment*

**TP.SS 06.18** *Confined space entry requirement s for Transpower sites*

**TP.SS 06.26** *Vehicle use in off-road situations*

**The Transpower Way** – A project management manual for Grid Projects

**Project Governance** – *Roles and Responsibility Model* – Draft Standard

### 8.1.2 Supporting Documentation

Alternative Construction Methods for Transmission Towers – Specific Site Study: David Stevens

JI231 Claim August 2013 - :\GRID PROJECTS\NI North\Projects - Active (P - F)\Bush Wrk-Wkm-C (Ring)\7. Construction\7.01 Civil, Access and Foundation\Brian Perry Civil\7.01.09 Invoicing\J231 Claim August 2013.xlsx

# Appendices

## A1: Images of construction work on tower 157 on the BHL-WHN A Line 2013

**Figure 3: A track mounted drilling rig climbs a tempory access track**

**Figure 4: A bucket of concrete is delivered to site for foundation works**

**Figure 5: A pre-assembled tower panel is delivered to site for later erection by gin pole**

**Figure 6: The gin pole used by a UK subcontractor to erect tower 157**

# A2: Helicopter concrete delivery performance

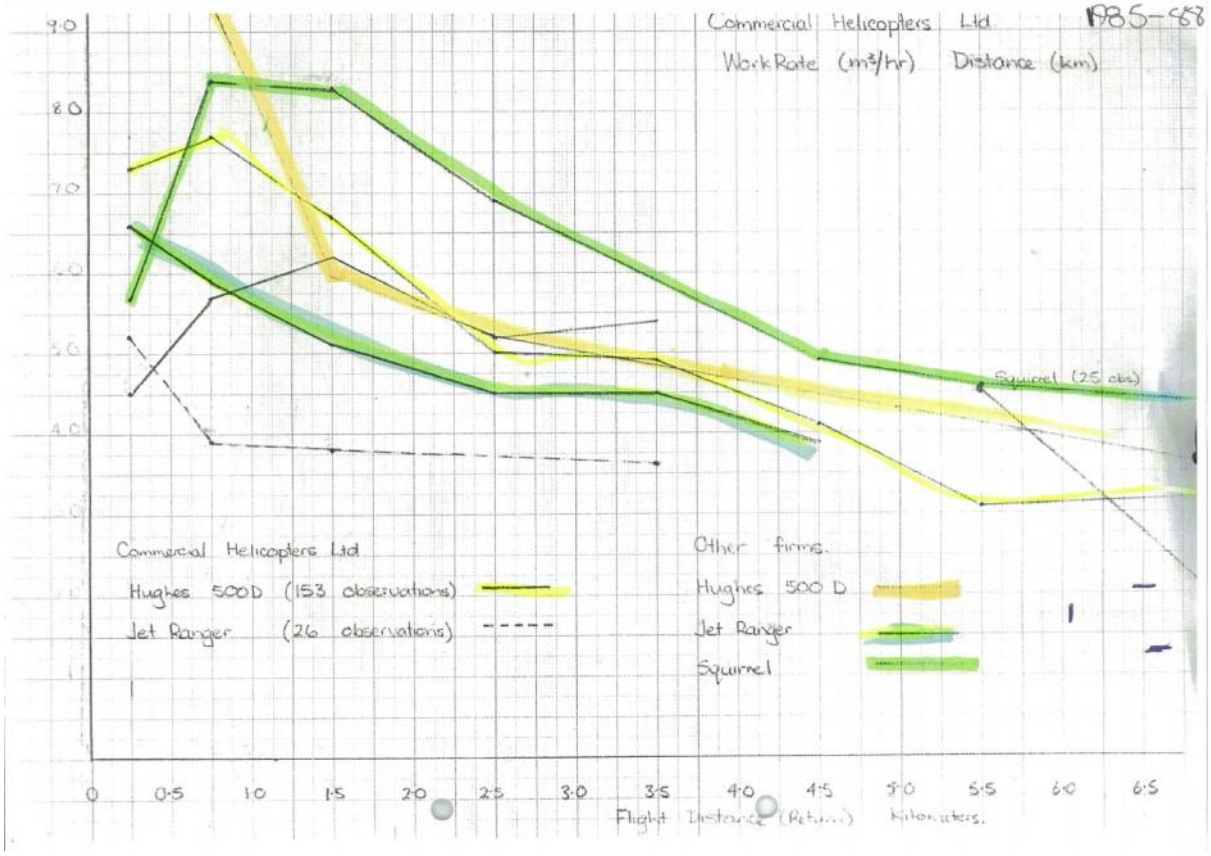



**Figure 7: 1988 helicopter concrete delivery performance (y-axis m^3/h of concrete delivered, x-axis km flight distance); sourced from Steven Notman – Transpower Safety Practitioner**

# B1: Risk Profile Comparison

**Table 13: Risk profile comparison process descriptors for tower erection by helicopter and crane; sourced from Northern Grid Alliance Job Hazard Analysis and HELiPRO Risk assessment form**

| Process Step | Description |
|---|---|
| **1** | Personal arrive at site |
| **2** | Plant and equipment |
| **3** | Personnel |
| **4** | Hazards associated with work task |
| **5** | Access site |
| **6** | Preparation of work area |
| **7** | Communication |
| **8** | Assembly/Ground Revision |
| **9** | Lifting operations with crane/helicopter |
| **10** | Rigging loads |
| **11** | Use of tag lines |
| **12** | Climbing and working on towers |
| **13** | Connecting module assemblies |
| **14** | Aerial revision |
| **15** | Pack up and leave site |

# C1: Twin engine helicopter performance classes

**Table 14: Twin engine helicopter performance classes; from TP.SS 02.08 *Use of Helicopters***

| Class | Performance Description | | Momentary height loss (Note 2) |
|---|---|---|---|
| | ICAO definition. | Transpower interpretation | |
| PC 1 | Operations with performance such that in the event of a critical power unit failure, performance is available to enable the helicopter to safety continue the flight to an appropriate landing area unless the failure occurs prior to reaching the take-off decision point (TDP) or after passing the landing decision point (LDP) in which cases the helicopter must be able to land within the rejected take-off or landing area. | The helicopter is capable of 200ft per min minimum rate of climb on one engine, and sustained normal flight operations on a single engine, without use of emergency power levels. Emergency forced landing not required in the event of a single engine failure | None or minimal |
| PC 2 | Operations with performance such that in the event of a critical power failure, performance is available to enable the helicopter to safely continue the flight to an appropriate landing area except when failure occurs early during the take off manoeuvre or late in the landing manoeuvre, in which case a forced landing may be required. | The helicopter is capable of 200 ft per min minimum rate of climb on one engine for a short period perhaps using emergency power levels. Planned emergency landing required. | Potentially several metres |
| PC 3 | Operations with performance such that in the event of a power unit failure at any time during the flight, a forced landing will be required. | The helicopter is incapable of generating enough power on one engine to maintain useful flight capability. Immediate emergency landing inevitable. | 10s of metres followed by a steady descent |

***Note 1:*** *The classes listed in **Table G1** above relate ONLY to twin engine (turbine) helicopters, and are not relevant to single engine machines.*

***Note 2:*** *When a twin engine helicopter suffers a sudden power loss on one engine, a momentary height loss may occur before the second engine comes up to full power. The amount of this height loss is dependent on many factors such as power rating at the time, altitude, pilot reaction time, etc, but is nevertheless critical when suspending workers close to the ground, to ensure they will not strike the ground in the event of a engine failure.*

# D1: Site Specific Study

On the recommendation of an experienced project manager within Transpower, two site specific studies were conducted. The objective of conducting these studies was to gain a comprehensive understanding of the limitations and barriers faced by project managers during real refurbishment situations. A report was prepared based on the findings of the site specific study and subsequent recommendations were made. The full report can be seen as supporting documentation.

## D1.1 Method of Analysis

The two specific transmission tower sights that were selected were:

1. Tower 50 on the Oteranga Bay Terminal Station to the Haywards Substation line (OTB-HAY A)

2. Tower 16 on The Central Park to Wilton B line (CPK-WIL B)

The two transmission towers were selected for the following reasons:

- The proximity to Transpower's Wellington office to allow for site visits
- The proximity to public roads so site visits can be completed without requiring private property access
- The towers will undergo refurbishment within ten years with the potential for full tower replacement
- The towers have been identified as sites that will present difficulties for access and construction due to their geography

The method used to assess what form of site access for major transmission tower refurbishment is appropriate from an economic view only is illustrated in table 15 below.

**Table 15: Method of site specific study**

| Step | Activity | Comments |
|---|---|---|
| **1** | Establish refurbishment work required | Assume tower and foundation replacement |
| **2** | Establish tower replacement type | Assume like for like |
| **3** | Review access | The student has limited civil knowledge so accuracy of track length etc. is questionable |
| **4** | Create cost estimate of developing access tracks capable of heavy machinery access to construction site | Cost estimates based on TEES 2013 and WRK-WKM C 2013 rates as bid (1) |
| **5** | If cost is excessive then explore other options – Construction by helicopter, gin pole etc. | 'Excessive cost' is yet to be determined |
| **6** | Report on any issues that prevent exploring alternative options | Issues are far reaching such as competencies held by service providers, available machinery or equipment and insufficient data available |

- Note (1): The Wairakei – Whakamaru C Line (WRK-WKM C Line) is currently in the final stages of construction. 105 towers and approximately 91,800m of access track to be constructed. Real, as bid quotes for civil works are readily available from this project.

The assumptions made to develop the cost estimates for steps 4 and 5 in table 15 can be seen below in table 16.

**Table 16: Cost comparison assumptions for traditional access method vs utilising helicopters**

| Traditional Method | Equivalent to / Compare to | Utilising Helicopters |
|---|---|---|
| Build access track + major construction plant (crane) | Compare to | Helicopter operation |
| Materials and delivery/removal to/from site | Equivalent to | Materials and delivery/removal to/from helicopter base of operations |
| Foundation drilling operations | Equivalent to | Foundation drilling operations (rig delivered by helicopter) |
| Form tower site crane pad | Compare to | Ensuring helicopter base of operations is cleared |
| Ground crew and rigging crew | Equivalent to | Ground crew and rigging crew |

| | | |
|---|---|---|
| Proof drilling and other preliminary work | Equivalent to | Proof drilling and other preliminary work |

## D1.2 Site Specific Study Results

The cost estimates in this section were quality checked by HELiPRO and compared with similar works on the Brownhill to Whakamaru North Line and Wairakei Ring project. The work by alternative access methods was deemed feasible at a high level by HELiPRO, Helicopters Otago Ltd, CW Drill Ltd. and Civil Works Ltd.

### *D1.2.1 Site 1*

**Table 17: Cost estimate of implementing an access track**

| Method of Estimation | Total | Confidence | Comments |
|---|---|---|---|
| WRK-WKM as bid rates | $105,000 | Low | Based on Tuaropaki access estimate, only includes obvious works |
| WRK-WKM average track cost per meter | $334,000 | Average | A reasonable estimate assuming similar access track requirements as for WRK-WKM |
| TEES | $108,000 | Low | TEES estimation does not account for particularly difficult access situations |

- Note: The access track has no future value

**Table 18: Cost estimate of crane operation**

| Method of Estimation | Work Description | Total | Confidence | Comments |
|---|---|---|---|---|
| TEES | Tower dis-assembly | $9,800 | High | Truck mounted crane 80 Tonne, $4,900 per day |
| TEES | Tower assembly | $9,800 | High | Truck mounted crane 80 Tonne, $4,900 per day |
| None | Crain pad construction | $ | None | No readily available information |

**Table 19: Cost estimate to utilise a helicopter for material delivery and construction**

| Description | Total | Confidence | Comments |
|---|---|---|---|
| Base of operations, clear and reinstate | $4668 | Low | Site visit not conducted, no land owner communication |
| Tower removal | $16,225 | Average | The efficiency of the ground crew has a large effect on the speed at which helicopters can transport loads |
| Foundation works | $23,766 | Average | |
| Tower erection | $22,125 | Average | |
| Contingency (weather) | $17,700 | Low | Assumed to be 3 days (windy area), HELiPRO does not charge for weather days |
| **Total** | **$84,484** | Low - Average | After review from a HELiPRO pilot and operations manager this estimate is conservative |

- Note: This cost estimation is the **additional** cost of building dismantling and erecting a C460 transmission tower as outlined in table 15.

By comparing cost estimates illustrated in table 17 and table 19, it is clear that an in depth economic analysis is required to justify implementing an access track.

### *D1.2.2 Site 2*

**Table 20: Cost estimate of implementing an access track upgrade**

| Method of Estimation | Total | Confidence | Comments |
|---|---|---|---|
| WRK-WKM as bid rates | $40,954 | Average | Expected to be a high estimate as some sections of the track may need patching only |
| WRK-WKM average track cost per meter | $307,367 | Low | A poor estimate as the access required is not similar to an 'average' WRK-WKM track as it requires an upgrade only |
| TEES | $42,406 | Average | Expected to be a high estimate as some sections of the track may need patching only |

- Note: The access track has future value

**Table 21: Cost estimate of crane operation**

| Method of Estimation | Work Description | Total | Confidence | Comments |
|---|---|---|---|---|
| **TEES** | Tower dis-assembly | $11,400 | High | Truck mounted crane 100 Tonne, $5,700 per day |
| **TEES** | Tower assembly | $11,400 | High | Truck mounted crane 100 Tonne, $5,700 per day |
| **None** | Crane pad construction | $ | None | No available information |

Due to the relatively low cost estimate to reinstate the required access track, a traditional access is recommended. No CBA is necessary to compare traditional access with alternative access methods.

## D1.3 Site Specific Study Issues

**Table 22: Issues encountered during site specific studies**

| | Site 1 Issues | | |
|---|---|---|---|
| **Issue No.** | **Issue** | **Impact** | **Comments** |
| **1** | TEES has little cost information on dismantling towers | Cost to dismantle towers not readily available | Assumed similar cost to tower erection during cost estimation |
| **2** | TEES is not designed to estimate access costs to particularly difficult sites | Lower accuracy of cost estimates | -Potential to use a cost multiplier |
| **3** | Uncertain of WBS for helicopter construction | Lower accuracy of cost estimates | -May have value to map the process to give a more detailed cost estimate |
| **4** | Use of gin poles considered a dying art in New Zealand | Gin pole construction may not be available of use in the near future | -May have value to map the process<br>-Transpower may have responsibility to ensure competencies exist<br>-Potential for a project to investigate if gin pole construction capabilities should be maintained or allowed to die out |
| **5** | Unknown weather contingency required | Construction times variable | -HELiPRO have no charge for weather days except for crew accommodation recovery costs |
| **6** | Information of tracked concrete trucks not readily available | Difficult to estimate costs involved and assess feasibility of use | -Tracked concrete trucks and buggies may allow for a more cost effective solution that using a helicopter to deliver concrete |
| **7** | Financial impact of flying near residential housing unknown | An increase in the cost of using helicopters for construction | -5.3.10 of TP.SS 05.20 *Stakeholder liaison*<br>-The cost increase is unknown<br>-Helicopter operator required extra paperwork but is still feasible |
| **8** | Availability of helicopters within NZ that meet Transpower requirements for construction operations unknown | Creates uncertainty initial feasibility of projects when performing 'back of the envelope' calculations | -Appendix D TP.SS 02.08 *Use of Helicopters*<br>-No HELiPRO or Helicopter Otago helicopters meet Transpower's standards due to no airframe fuel filter fitted |
| **9** | Unknown availability of competent pilots that meet Transpower requirements | Creates uncertainty initial feasibility of projects when performing 'back of the envelope' calculations | -6.4 TP.SS 02.08 *Use of Helicopters* |
| **10** | TP.SS 02.08 *Use of Helicopters*, restricts entry to work for pilots | TP.SS 02.08 may create such a high barrier to entry for new pilots that competencies die out | -20 hours logged transmission line work required etc.<br>-Transpower may have some responsibility to ensure competencies exist |

| | | | |
|---|---|---|---|
| **11** | A risk that helicopter operators will neglect competencies due to lack of return on investment | Possible for a monopoly to develop | -For high risk work like transmission tower construction, operators would prefer to set a minimum hours per year requirement to maintain competency and pay back specific training requirements<br>-Transpower needs to ensure a monopoly doesn't develop by ensuring a minimum amount of work given to preferred suppliers<br>-A risk may develop where operators will deny work based on risk |
| **12** | Micro-pile and similar foundation methods largely unused by Transpower | Reduces possible options for construction methods, especially helicopter portable drilling rigs | -TP.DL 01.01 *Transmission Line Foundation Design*<br>-Transpower may want to adopt a standard design if many micro piles will be used in future |
| **13** | Many assumptions are needed to create a cost estimating tool that covers all access and refurbishment possibilities | A poor return on time investment | -A register has been proposed which allows Project Managers to make appropriate assumptions and create a cost estimate built up from the supplied information |
| **14** | Comparing the risk of different construction methods is difficult | Justification of utilising helicopters is difficult | -6.1.1 TP.SS 02.08 *Use of Helicopters*<br>-Comparing risks is difficult as information is normally qualitative, not quantitative |

| | **Site 2 Issues** | | |
|---|---|---|---|
| **15** | Future value of access tracks unknown | Justification of utilising helicopters is difficult | - 8.3.1 TP.SS 02.19 *Management of access ways*<br>-Standard demands an economic analysis of the benefits of using alternative access to give the best result for **long-term** lowest cost which incorporates the future value of an access track |
| **16** | Contradicting standards: 8.3.1 TP.SS 02.19 *Management of access ways* **vs** 6.1.1 TP.SS 02.08 *Use of Helicopters* | Makes justification of method chosen difficult for Project Managers | -TP.SS 02.19 states that: The method of access provided is to be that which achieves the best result for the lowest long-term cost<br>-TP.SS02.08 states that: Helicopters will only be used when alternative methods have a poorer safety risk profile, and/or other methods have a **disproportionately** greater cost |

### D1.4 Site Specific Study Recommendations

The following recommendations have been made in light of completing the site specific studies:

1. The proposed tool development should be discontinued
2. An 'Alternative Construction Methods' register should be created containing:
    a. Up to date, relevant information on the availability and capabilities of machinery
    b. Up to date, relevant information on the availability and capabilities of crew and operators
    c. High level process maps for delivering the methods
    d. An analysis of the future value of access tracks
3. A review of the procurement process specific to helicopter operations should be considered
4. A review of gin pole construction to determine:
    a. If the technique should be allowed to die out
    b. If the technique should be maintained; in which case the following work should be completed:
        i. Determine the current state of competencies and gear standards
        ii. Complete a project to ensure the technique can be relied upon in the future

## E1: Project management tools and techniques

**Table 23: Tools and techniques used throughout the project process**

| Project Management Tools and Techniques Tracking | | | |
|---|---|---|---|
| **Project Phase** | **Tool/Technique** | **Rational** | **Notes** |
| Conceptual phase | Improvement analysis A3 | Used to initially define the problem and what the preferred future state would be. Also an effective way to communicate potential projects to stakeholders including senior management | Was useful to realise what information was needed to 'pitch' the project<br>Was useful in communicating the intended project to stakeholders |
| | Communication plan | To ensure effective communication occurs between stakeholders. | |
| | Stakeholder analysis | Essential for a successful project. | Using a changing model depending on project phase. |
| | Weighted Matrix | To determine which potential project best fulfilled the project requirements | |
| | Lessons learnt register | Used to benefit the project and person development | |
| Planning phase | Responsibility matrix | To clearly define who in the team is responsible for what | Not used so far, roles have instead evolved |
| | Comms plan | Created to satisfy MEM requirements | Required thought but seemed to be more limiting than enabling early on. For a project of this size the comms plan only needs to be very simple |
| | Milestone chart | To realise when milestones should be completed and to convey to stakeholders | Displayed as a table in the project plan and in the project schedule |
| | WBS | Best practice | Very helpful to create schedule and to gain an understanding of the project, will be a living document |
| | Project Charter | To use as a brief project plan to bring stakeholders up to speed on the project | Used as more of a project plan summary |
| Execution Phase | Project change request | Required to inform PAT and project team of project changes | Was received well, clearly demonstrates the changes recommended and the impact that this will have on the project |
| | Flow chart | To map the project managers decision making process | Was later discontinued in favour of BPM process mapping |
| | Lessons learnt | Used to benefit the project and person development | Have referred to the lessons learnt register to familiarise my self with past mistakes when undertaking a new project |
| | WBS | Is kept current to refer to during execution | Was helpful though was poorly constructed initially resulting in a fall behind schedule due to an over ambitious schedule |
| | BPM process mapping | Clearly illustrates process | BPM tool Bizargi is Transpower's method of process mapping |

**Table 24: A list of tools and techniques from Paranakul, Lewwongcharoen and Milosevic's paper, *An empirical study on the use of project management tools and techniques across project life-cycle and their impact on project success***

| Conceptual phase | Planning phase | Execution phase | Termination phase |
|---|---|---|---|
| T01 Analogous estimate<br>T02 Bar chart<br>T04 Brainstorming<br>T07 Checklist<br>T08 Communication plan<br>T13 Customer visits<br>T28 Project charter<br>T32 Scope statement<br>T35 Stakeholder analysis<br>T39 Work Breakdown Structure (WBS) | T01 Analogous estimate<br>T02 Bar chart<br>T03 Bottom-up estimate<br>T04 Brainstorming<br>T07 Checklist<br>T08 Communication plan<br>T09 Contingency plan<br>T10 Cost baseline<br>T11 Critical Path Method (CPM)<br>T13 Customer visits<br>T15 Flowchart<br>T17 Hierarchical schedule<br>T19 Milestone analysis<br>T20 Milestone chart<br>T25 Performance report<br>T26 Project change log<br>T27 Project change request<br>T28 Project charter<br>T29 Responsibility matrix<br>T30 Risk response plan<br>T32 Scope statement<br>T35 Stakeholder analysis<br>T39 Work Breakdown Structure (WBS) | T02 Bar chart<br>T03 Bottom-up estimate<br>T04 Brainstorming<br>T07 Checklist<br>T08 Communication plan<br>T09 Contingency plan<br>T10 Cost baseline<br>T11 Critical Path Method (CPM)<br>T13 Customer visits<br>T15 Flowchart<br>T17 Hierarchical schedule<br>T18 Lessons learned<br>T19 Milestone analysis<br>T20 Milestone chart<br>T24 Performance measurement baseline<br>T25 Performance report<br>T26 Project change log<br>T27 Project change request<br>T29 Responsibility matrix<br>T30 Risk response plan<br>T31 Schedule crashing<br>T32 Scope statement<br>T39 Work Breakdown Structure (WBS) | T02 Bar chart<br>T07 Checklist<br>T08 Communication plan<br>T10 Cost baseline<br>T13 Customer visits<br>T18 Lessons learned<br>T19 Milestone analysis<br>T20 Milestone chart<br>T25 Performance report<br>T26 Project change log<br>T27 Project change request<br>T29 Responsibility matrix<br>T32 Scope statement<br>T39 Work Breakdown Structure (WBS) |

# F1: Project advisory team model

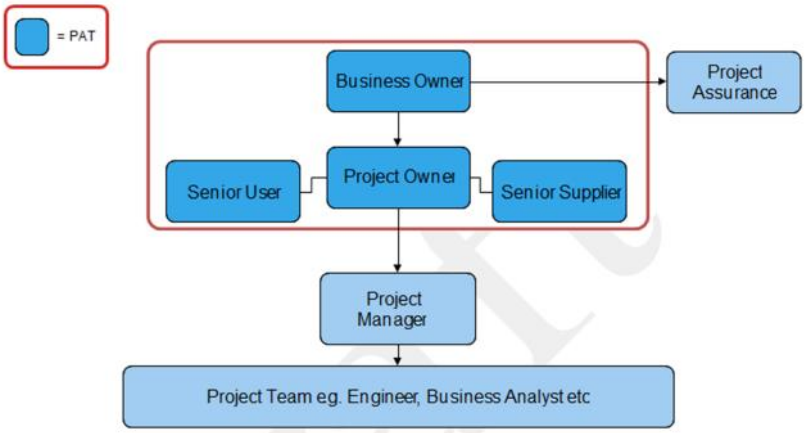
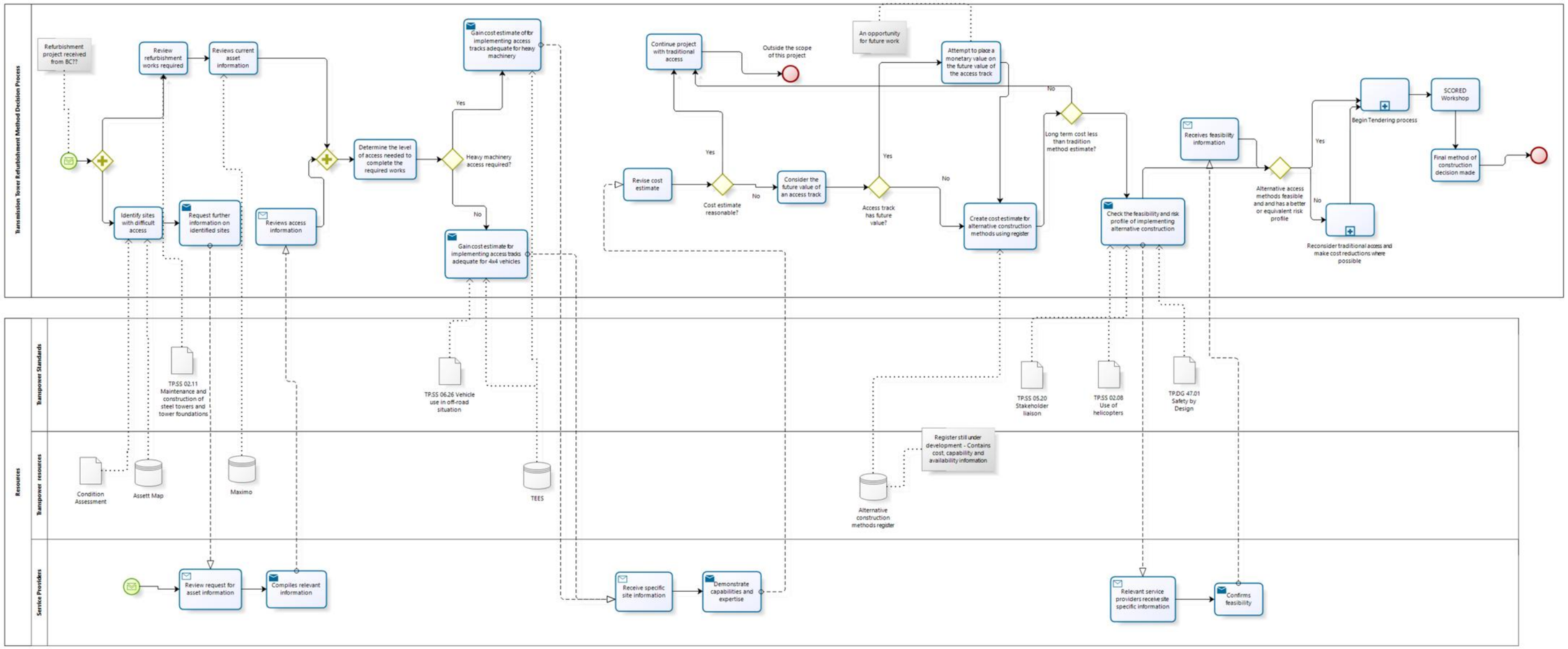
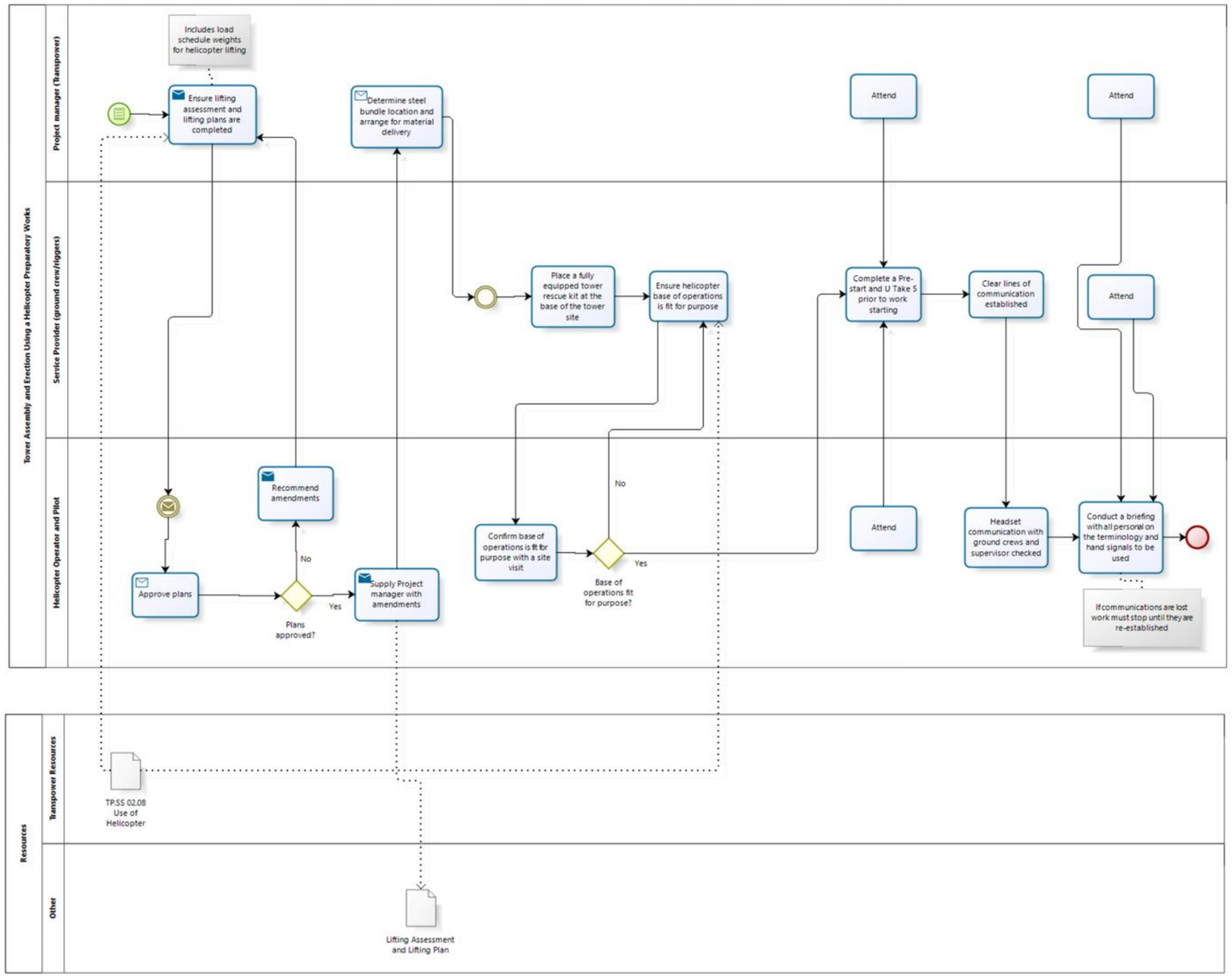



**Figure 8: Project Advisory Team Model (PAT) sourced from Transpower document Project Governance**

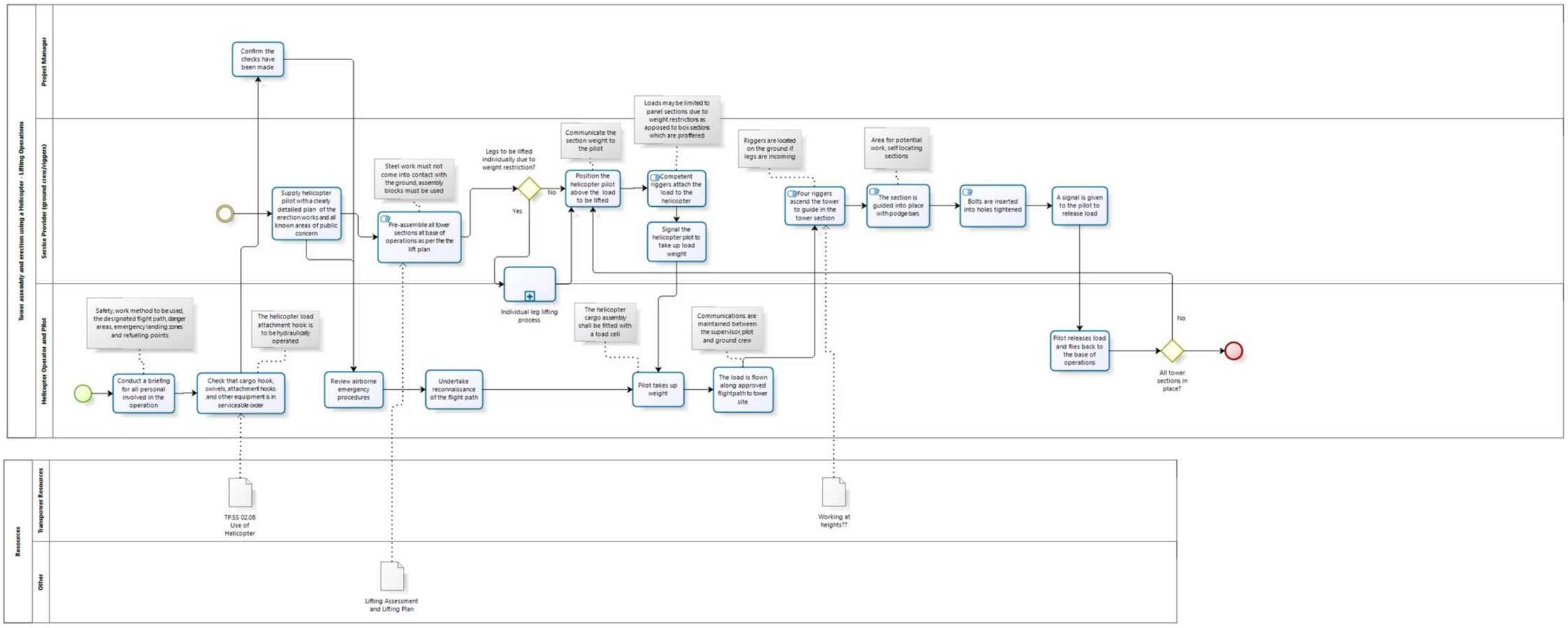
## G1: Project manager access way decision making process map

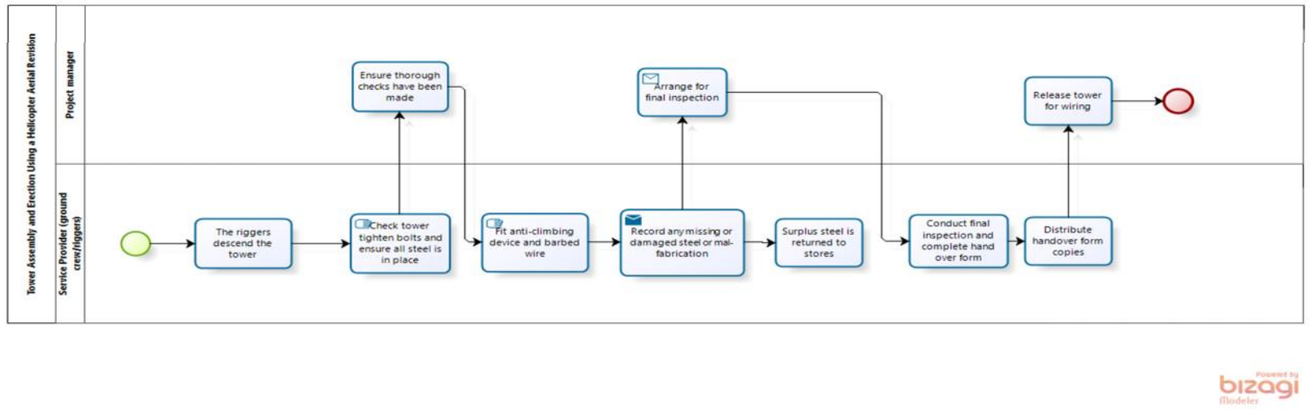


## G2: Tower Assembly and erection using a helicopter – preparatory works process map



## G3: Tower Assembly and erection using a helicopter – lifting operation process map



# H1: Stakeholder management tool

| Stakeholder Details | | | | | Classification | | Can Impact Project | | Can Be Impacted By Project | | | Stakeholder Involvement | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stakeholder | Company | Position | Contact Details | Project Role | Power | Interest | Positive Impact | Negative Impact | Positive Impact | Negative Impact | Management Grouping | Conceptual Phase | Planning Phase | Execution Phase | Last reviewed | Notes |
| Kevin Small | TP Grid Projects | General Manager Grid Projects | 7174 | Business Owner | High | Low | Yes | Yes | Yes | No | Keep Satisfied | Low | Low | Low | 24/10/2013 | Contact Melanie Wright - 7364 |
| Nick Coad | TP Grid Projects | Grid Works Project Manager | 7081 | Project Assurance | High | High | Yes | Yes | Yes | Yes | Manage Closely | High | High | | 24/10/2013 | |
| Vivien Winch | TP Grid Projects | Programme Delivery Manager | 6979 | Project Owner | High | High | Yes | Yes | Yes | No | Manage Closely | High | High | | 24/10/2013 | |
| Peter Cahill | TP Grid Projects | Projects Manager | 7650 | Senior User | High | High | Yes | Yes | Yes | Yes | Manage Closely | Low | High | High | 25/10/2013 | Completing work that could potentially use the results of this project within the next two years |
| Christian Carter | TP Grid Projects | Project Support and Services Manager | 6637 | Senior Supplier | High | Low | Yes | Yes | No | No | Keep Satisfied | None | Low | | 24/10/2013 | Confirmed to be on Project governance team |
| | | | | | | | | | | | | | | | | |
| Jason Price | TP Grid Projects | Delivery Improvements Manager | 7265 | Mentor | High | High | Yes | Yes | No | No | Manage Closely | High | High | High | 25/10/2013 | Have established fortnightly meetings to use as checkpoint updates |
| Peter Rasul | TP Grid Projects | Transmission Lines Construction Grid Projects | 7068 | Engineer | High | High | Yes | Yes | Yes | Yes | Manage Closely | Low | High | High | 25/10/2013 | Confirmed to be on Project team |
| Steven Notman | TP Grid Projects | Safety Practitioner | 6442 | Safety information | Low | High | Yes | Yes | Yes | No | Keep Satisfied | None | Low | High | 3/12/2013 | Safety information. Has experience and thinks positively about the project. Doesn't see any obvious safety issues. Works out of Hamilton |
| Gavin Murray | TP Grid Projects | Programme Manager | 7447 | Engineer | High | High | Yes | Yes | Yes | Yes | Manage Closely | Low | High | | 25/10/2013 | Knowledge of upcoming projects that this project will be helpful with |
| | | | | | | | | | | | | | | | | |
| Roy Noble | TP Grid Development | Asset Engineering Manager (Lines) | 6897 | | | | Yes | Yes | | | | None | Low | | 25/10/2013 | |
| Derek Kooman | Electrix | Regional Manager | derek.kooman@electrix.co.nz | Technical advice | Low | Low | Yes | No | No | No | Monitor (Minimum Effort) | None | Low | Low | 14/11/2013 | Experienced mostly using gin poles and cranes, happy to help from a high level. Has got back to me with pros and cons |
| Jim Hastie | Electrix | Contractor | 03 440 0120 | Technical advice | Low | Low | Yes | No | Yes | No | Keep Informed | None | Low | High | 20/11/2013 | Happy to help. Experience with helicopter use. Have engaged via email to find out where his expertise lies, what information he has for me etc. Happy to walk through a process map etc. Has built towers, poles and wood poles with helicopters |
| John Claridge | Transfield | Contractor | claridgej@transfieldservices.com | Technical advice | Low | Low | Yes | No | No | No | Monitor (Minimum Effort) | None | Low | Low | 21/11/2013 | Happy to help. Experience with helicopter use. Been in industry for over 30 years, used helicopters in the 70's, 80's 110kV in Wellington (no longer exists) |
| Jeff Edhouse | TP Grid Development | Project Manager | 6453 | Costing information | | | | | | | | | | | 18/11/2013 | Costing information |
| | | | | | | | | | | | | | | | | |
| Rob Batters | TP Grid Projects | Programme delivery manager | 6151 | Technical advice | | | | | | | | | | | 18/11/2013 | Wairakei Ring information |
| Russell Bush | TP Grid Projects | Projects | 6458 | Technical advice | | | | | | | | | | | 18/11/2013 | Wairakei Ring information |
| Craig Tibbitts | TP Grid Projects | Project Controls Engineer | 6311 | Costing information | | | | | | | | | | | 18/11/2013 | Costing information |
| Russell Bolt | TP Grid Development | Senior Lines Engineer | 7627 | Technical advice | Low | Low | Yes | Yes | Yes | No | Keep Informed | None | Low | Low | 1/12/2013 | Started on the tools, has used helicopters before, encouraging of the project |
| Jon Mason | TP | Project manager | 6061 | Technical advice QA | High | High | Yes | Yes | Yes | No | Keep Satisfied | None | High | High | 6/12/2013 | Based in Palmiston North, have sent an inquiry email. Happy to help and be a QA. Heaps of experience. |
| Martin Chalk | TP Grid Development | Estimation manager | 7189 | Costing information | Low | Low | Yes | Yes | Yes | No | Keep Informed | None | High | High | 19/12/2013 | Had meeting and was delivered cost information, can supply r |
| | | | | | | | | | | | | | | | | |
| Ned Lee | HELiPRO | Central Regions Operations Manager | 04-472 1550 | Technical advice | Low | High | Yes | Yes | Yes | No | Keep Informed | None | Low | High | 24/01/2014 | Sent specific Questions to Ned |
| Skywork | Skywork | | 0800 759 9675 | | | | | | | | | | | | 7/01/2013 | Sent an invite to talk |
| Graeme Gale | Otago Helicopters | CEO | 03 489 7332 | Technical advice | Low | High | Yes | Yes | Yes | Yes | Keep Informed | None | None | Low | 24/01/2014 | Recommended by Jim Hastie, Contact Dave Gale 03 489 7332 offer of assistance, email Kevin Gale on 13/1/2014 |
| Ben Juet | Civil Group | Managing director | Prefer email | Technical advice | Low | High | Yes | No | Yes | Yes | Keep Informed | None | None | Low | 25/01/2014 | Has sent good info on capabilities |
| James Chapman | CW Drilling | Managing director | 0800 429 374 | Technical advice | Low | High | Yes | No | Yes | Yes | Keep Informed | None | None | Low | 26/01/2014 | Has discussed good info on capabilities and costs |

# I1: Lessons Learned Register

| Lesson Title | Date | Category / Source | Description of Lesson | Impact / Consequence | Solution / Recommendations for Future Projects | Action Taken | Efficiency & Benefit Realisation | Project |
|---|---|---|---|---|---|---|---|---|
| People skills | 4.10.13 | People management | The approach taken in engaging Christophe regarding the transformer pad potential project was poor. I met him at his desk and did not introduce myself properly and did not clearly state why I had interest in 'taking over' his | Potentially the loss of a good potential project and a loss of credibility from a key stakeholder | Before meeting a stakeholder (internal or external) begin with a clear introduction of position and purpose etc. Allow time to accept meetings with all relevant | Attitude readjustment | Better engagement of stakeholders | MEM masters |
| People skills | 11.10.13 | People management | In creating project proposals, little thought was given to who the audience was. | The proposals are being updated | Think who the audience will be for proposals and similar documents. Think about what information they require to make an informed | Noted | Better engagement of stakeholders | MEM masters |
| understanding large organisations | 13.10.13 | Data | It can take a very long time to source data in a large organisation. Often, the data is that is sourced is in an unusual format or is missing key areas | Project delays | Not the time taken to source data and plan accordingly. Build a network of people that know where information is held. | Noted | Less time waste | MEM masters |
| Due-diligence | 15.10.13 | Project Management | I have been given potential projects that I then accessed and began to scope up before I completed proper due-diligence. Two of the projects I was in the process of scoping were either already completed or half way through. | Time wasted in scoping projects, doubling up of work | Before taking a project at face value and moving forward with it, take a step back and see what has been completed to date in this area, ask who is in charge of or | Change in approach | Less time waste | MEM masters |
| Meeting Preparation | 24.10.13 | People management | I circulated information relevant to the meeting the morning of. | Key stakeholders for my project did not have time to consider the information I circulated before the meeting allowing the meeting to be | Circulate relevant information well in advance to meetings | Noted | Better engagement of stakeholders and better use of meeting time | MEM masters |
| Senior management presentations | 24.10.13 | Project Management | Provide an agenda for a meeting and attempt to stick to it.<br><br>Be confident in the information presented | Low, however could have made a better impression on senior management | Practice and prepare | Noted | A more effective presentation | MEM masters |
| Requirements gathering | 19.11.13 | Project Management | Gathering requirements takes more than just a few days. Preparation is key. A box saying 'gathering requirements' is not enough. Requirements also have to be approved which | Slightly behind schedule. Had to start research phase before requirements gathering phase has been completed | Allow more time. During stakeholder identification, try to establish who is to give requirements. | Had to lengthen schedule | Next time will be on time | MEM masters |
| Approvals | 20.11.13 | People management | Managers can be resistant to officially put their name down for approval. | None yet but could result in denial or lack of accountability | Be clear and firm that a proposal, plan, requirements document etc. needs approval from who, when | Noted | A more robust PM process in future | MEM masters |
| Approvals | 21.11.13 | People management | Make sure that when approval is sort after state exactly what is expected eg: 'Approval must be confirmed or denied by xxxx date by xxxxxx | A change request that was sent out has not been acted upon | Be clear and concise about what is expected of the approvers | Noted | A more robust PM process in future | MEM masters |
| Managing stakeholder expectations | 13.01.14 | People management | The expectations of a company were not managed well during information sourcing. | The managing director of Civil Group emailed me offering assistance beyond what was necessary | Manage expectations from the beginning of correspondence ie: 'This is for research purposes only' etc. | Noted | A more robust PM process in future | MEM masters |
| Managing stakeholder expectations | 17.01.14 | Project Management | I have expected my final project report to be marked by members of my PAT and Project Team before the 7/2/2014. I have known about this for some time and am yet to book time or consult the necessary people. | The relevant stake holders may not have time to review and comment on my project. This will incur a fail mark for MEM so is extremely important. | Inform stakeholders as soon as possible, book place holder time in advance. Discuss the expectations of the stakeholders | Sent placeholders and communicated expectations | A more robust PM process in future<br><br>Ensuring better use of important stakeholder time | MEM masters |